Attachment A

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

California Department of Water Resources	)	
	)	**P-2100**
Oroville Facilities	)	

COMMENTS ON DRAFT ENVIRONMENTAL IMPACT STATEMENT

BY

COUNTY OF PLUMAS
AND
PLUMAS COUNTY FLOOD CONTROL & WATER CONSERVATION DISTRICT

Magalie R. Salas, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, DC 20426

Dear Ms. Salas:

The County of Plumas and the Plumas County Flood Control and Water Conservation District (collectively, "Plumas") hereby submit the following comments on the Draft Environmental Impact Statement ("DEIS") prepared for the application for a new license for FERC Project 2100 (the "Oroville Facilities").

Introduction

Plumas County and the Plumas County Flood Control and Water Conservation District appreciate the opportunity to comment on the draft Environmental Impact Statement for the relicensing of the Oroville Facilities. Plumas participated in the relicensing process that was undertaken using FERC's Alternative Licensing Procedures, but Plumas is not a party to the resulting settlement agreement because of significant operational and environmental concerns that were not addressed in the settlement. Plumas filed a motion to intervene in these proceedings in March 2006, explaining its concerns with the inadequacy of the settlement agreement.

Plumas County's concerns about fisheries impacts, flood control, cold water reserves, fish passage, and climate change impacts continue to be unresolved by the Staff Alternative or adequately addressed in the DEIS. The scope of analysis in the DEIS is overly narrow – largely because the wide-ranging impacts of operating the Oroville Facilities and the California State Water Project ("SWP") are not acknowledged. The No-action/Baseline Alternative is defined by the California Department of Water Resources ("DWR") as continuing to operate the project within one to two percent of the average historic variability of project operations. See Assessment of the Relationship of Project Operations and Recreation, Table 5.4-1 (May 2004). Such an assumption is unwarranted given recent changes in project operations and evolving environmental constraints. However, neither DWR's Proposed Action nor the Staff Alternative adequately recognize those changes or constraints or provide for any significant protection, mitigation, and enhancement measures ("PM&Es") to address many of the project's impacts.

The comments below explain how Plumas believes the DEIS must be revised to comply with the National Environmental Policy Act, 42 U.S.C. § 4321, et seq. ("NEPA"), and the Federal Power Act, 16 U.S.C. § 791a, et seq. ("FPA"), particularly with regard to the consideration of additional alternatives that account for known or likely operational changes and environmental constraints. Without significant revisions, the DEIS could be found inadequate in a court of law. In reviewing the adequacy of an EIS, the Ninth Circuit applies the "rule of reason" standard "which requires 'a pragmatic judgment whether the EIS's form, content and preparation foster both informed decision-making and informed public participation.'" Native Ecosystems Council v. U.S. Forest Service, 418 F.3d 953, 960 (9th Cir. 2005) (quoting California v. Block, 690 F.2d 753, 761 (9th Cir. 1982)). FERC has not taken the requisite "hard look" at the impacts of this proposed license and settlement agreement on flood control, irrigation, water supply, new operations, lake levels, fishery impacts, alternatives, or cumulative impacts.

Deficiencies of the DEIS Under the Federal Power Act

Section 10(a)(1) of the FPA, 42 U.S.C. § 803(a)(1), establishes the comprehensive development standard that each project must meet to be licensed. A licensed project shall be "best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of waterpower development, for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat), and for other beneficial public uses, including irrigation, flood control, water supply, and recreational or other purposes...." The DEIS fails to provide the necessary comprehensive plan because it ignores or understates important environmental issues that are affected by the proposed future operation of the Oroville Facilities.

A particular concern is the failure to adequately address the potential impact of changes in operations of the Oroville Facilities and the State Water Project that may be mandated as a result of federal and California laws protecting endangered species. Over the last 150 years, the Sacramento River has been engineered into a massive water delivery system which includes various dams that have blocked access to much of the historical habitat of anadromous fish. Development of the basin's water resources has, in effect, initiated a large-scale ecological experiment. The experiment examines whether the historical habitat templates and their associated salmon and steelhead production systems can be relocated below the migration barriers. This undertaking has, so far, put three of the basin's four evolutionary significant units ("ESUs") at risk of extinction: steelhead and winter-run and spring-run Chinook salmon in the Sacramento River are listed as endangered or threatened under the Federal Endangered Species Act ("ESA").

Deficiencies of the DEIS Under NEPA

NEPA was enacted by Congress in 1969 "to declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; [and] to enrich the understanding of the ecological systems and natural resources important to the Nation...." 42 U.S.C. § 4321. Despite this ambitious declaration of purpose, NEPA has been interpreted as essentially procedural. See Blue Mountains Biodiversity Project v. Blackwood, 161 F. 3d 1208, 1216 (9th Cir. 1998) (noting that the purpose of NEPA is to ensure a process, not to ensure any result). The NEPA process is designed to ensure "that the agency...will have available, and will carefully consider, detailed information concerning significant environmental impacts; it also guarantees that the relevant information will be made available to the larger [public] audience." Id. at 1212 (quoting Robertson v. Methow Valley Citizens Council, 490 U.S. 332 (1989)).

NEPA requires FERC to prepare a detailed EIS for all "major Federal actions significantly affecting the quality of the human environment." 42 U.S.C. § 4332 (2)(c). An EIS must include a description and analysis of the environmental impact of the proposed action; any adverse environmental effects that cannot be avoided if the action is implemented; alternatives to the proposed action; the relationship between short-term uses and long-term productivity; and any irreversible or irretrievable commitment of resources that would be involved if the action were to be implemented. Earth Island Inst. v. U.S. Forest Service, 442 F.3d 1147, 1153 (9th Cir. 2006) (citing 42 U.S.C. § 4332 (2)(c). "In short, NEPA requires that a federal agency 'consider every significant aspect of the environmental impact of a proposed action' and 'inform the public that it has indeed considered environmental concerns in its decision-making process.'" Id. (quoting Kern v. U.S. Bureau of Land Mgmt., 284 F.3d 1062, 1066 (9th Cir. 2002)).

NEPA also mandates that an agency consider and discuss the range of all reasonable alternatives to the proposed action, to "provid[e] a clear basis for choice among options by the decision-maker and the public." 40 C.F.R. § 1502.14. An agency is not required to extensively analyze alternatives that do not meet the purpose and need of the project. See Laguna Greenbelt v. United States Dep't of Trans., 42 F.3d 517, 523-525 (9th Cir. 1994). However, an agency may not narrowly define an action's purpose and need so as to winnow down the alternatives until only the desired one survives. See Klamath-Siskiyou Wildlands Center v. U.S. Forest Service, 373 F. Supp. 2d 1069, 1088 (E. Dist. Cal. 2004) (noting that, in the EIS context, one obvious way for an agency to slip past the strictures of NEPA is to contrive a purpose and need so slender as to define competing reasonable alternatives out of consideration).

The purpose of the proposed action should be described as operating the Oroville Facilities in the future to balance hydropower and downstream water supply benefits with environmental and recreational benefits in the face of considerable uncertainty. The purpose of the proposed action must acknowledge the controllable and uncontrollable factors in the Feather River basin – both upstream and downstream of the project – that will significantly affect operations during the new license period.

However, the DEIS defines the No-action/Baseline and the Proposed Action so narrowly that the most significant environmental constraints and environmental impacts related to project operations are outside the scope of analysis. The project purpose, by narrowly framing the scope of the DEIS analysis, becomes overly focused on the reliability of downstream water supply deliveries. In reality, new State Water Project operational flexibilities are already changing Oroville reservoir and other project operations. It is likely that operational variability will increase further over time in response to new water management authorities and changing conditions.

Inadequate Disclosure and Analysis of the No-action/Baseline Alternative

The No-action Alternative is presented in such a way that the reader is unable to verify the claims that the proposed future operations of the project will be largely similar to historic operations. NEPA does not permit an agency to rely on conclusions and opinions without providing supporting analysis and data. See Idaho Sporting Congress v. Thomas, 137 F.3d 1146, 1150 (9th Cir. 1998). Also, an agency must evaluate and disclose credible scientific evidence that contraindicates a proposed action. See 40 C.F.R. § 1502.9(b).

FERC has not met the "hard look" legal standard as to scientific integrity, complete disclosure, and analysis in the DEIS. The way the baseline data is currently presented in the DEIS, it is difficult to distinguish between the influence of controllable and uncontrollable factors. Such a distinction is especially important because the project and the baseline are essentially the same except for the proposed PM&Es.

Hydrology is a largely uncontrollable factor for project operations. In contrast, the timing and volume of project storage and releases are predominantly controllable. The distinction is important because FERC has limited jurisdiction over hydrology but significant jurisdiction over hydroelectric project operations. Through FERC's mandatory license conditioning authority, FERC routinely imposes conditions on reservoir operations and downstream water releases in order to protect environmental and recreational values and to balance environmental and recreational benefits with hydroelectric operation benefits.

Water inflows (hydrology) and reservoir operations (water deliveries, minimum flow releases for downstream fish habitat, and controlled flood releases), all affect water levels in Lake Oroville. These key baseline factors need to be displayed as separable project effects to assist FERC in the formulation of real alternatives to the project and in developing sufficient PM&Es.

Inadequate Disclosure and Analysis of the Proposed Action

The final EIS and license must provide enforceable parameters for future reservoir operations to guarantee that the project will be operated in the future as it has been operated in the past. Without enforceable license conditions on reservoir operations, there is no real guarantee that negative environmental impacts will be avoided or adequately mitigated, which is the essence of complying with NEPA.

Under NEPA, FERC has the duty to identify, avoid, and mitigate the significant negative effects of the project, and it is unclear how that duty will be satisfied absent enforceable license conditions for reservoir operations. The mere assertion by DWR that water supply, flood control operations, and environmental conditions above and below the project will not change is not a legally sufficient basis for concluding that project impacts will not change during the term of a new license.

For example, the DEIS does not disclose or analyze differences between pre- and post-1995 project operations as a result of the Monterey Amendment to DWR's contracts with its water customers. New license conditions or additional PM&Es are needed to prevent or to mitigate impacts from continuing post-1995 operations over the term of the new license. The DEIS is too vague about what "historical" operations DWR proposes to continue, making it impossible to assess the environmental impacts of the project. Blending pre- and post-1995 operations obscures the actual environmental effects of the project.

NEPA establishes procedural requirements to ensure that agencies take a hard look at the environmental impacts of their actions. A hard look includes "considering all foreseeable direct and indirect impacts" of a federal action. Idaho Sporting Congress v. Rittenhouse, 305 F.3d 957, 973 (9th Cir. 2002). A hard look also includes a discussion of adverse impacts that does not improperly minimize negative side effects. Earth Island at 1154. FERC, therefore, must "undertake a thorough environmental analysis before concluding that no significant environmental impact exists." Native Ecosystems Council v. U.S. Forest Service, 428 F.3d 1233, 1241 (9th Cir. 2005).

Inadequate Disclosure and Analysis of the Need for Additional Alternatives

After reviewing State Water Project publications and considering existing environmental conditions both above and below Lake Oroville, it is apparent that both the inflow hydrology and the volume and timing of SWP deliveries have changed significantly since 1995 and that operation of the Oroville Facilities may change significantly in the future. The DEIS does not accurately reflect the recent changes in historical operations by DWR. FERC has the duty under NEPA to analyze the impacts of continuing these changed reservoir operations throughout the new license period because the factors that have precipitated project operational changes since 1995 will only intensify in the future.

At a minimum, the EIS should include analysis of two additional alternatives for licensing the operations of the Oroville Facilities:

- **Climate Change Alternative.** One alternative should include express license provisions that reflect project operations and PM&Es accommodating operational variability resulting from climate change impacts. As DWR itself has acknowledged, changed inflow hydrology will likely affect Oroville operations, especially in extremely wet and extremely dry periods.

- **Doubled Exports Alternative.** One alternative should include express license conditions that reflect project operations and PM&Es related to doubling SWP exports from the San Francisco Bay/Sacramento-San Joaquin Delta from the historic average of two million acre-feet per year to four million acre-feet. Doubling water deliveries from the historic average may significantly impact Oroville reservoir operations, especially in drought periods. The Doubled Exports alternative should incorporate the climate change variability discussed above or, alternatively, FERC could present analysis of the Doubled Exports Alternative with and without climate change variability.

Presented below is further elaboration on issues and data that should be taken into consideration in the analysis of each of the alternatives and in the consideration of cumulative impacts from the Oroville Facilities and other FERC-licensed projects.

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The No-action/Baseline Alternative Must Distinguish Between Controllable and Uncontrollable Factors

FERC has improperly allowed DWR to blend hydrology and SWP water deliveries as the baseline for analyzing historic and future reservoir operations and impacts. In addition to the confusing presentation of baseline data, the use of specific years to illustrate project effects – without explanation why these years were chosen for analysis – compounds the reader's confusion. Also, the pre-1995 Monterey Amendments and post-1995 Monterey Amendments part of the historical record are two distinct operational periods and those periods should be treated separately.

The DEIS should include the following information as footnotes to all tables and figures presented in the DEIS.

- The reason for the selection of specific years in the 73-year period of record that are displayed in tables and figures.
- Water supply volumes (Table A deliveries) for the same period.
- Table A deliveries displayed both in acre-feet and as a percent of maximum Table A deliveries allowed under the SWP water contracts.
- Downstream water releases from Oroville in cubic feet per second or acre-feet.
- The "water year" designation (wet, normal, dry, or critically dry)
- Lake Oroville's water level elevation(s).

This accompanying information would help provide context for the baseline and project impact data that is presented in the DEIS. Also, information generated from modeling versus information that displays actual inflow or operations data should be labeled clearly and consistently throughout the DEIS.

CALSIM II is used almost exclusively to predict future project impacts and in cases it is also used to simulate the historical baseline data. CALSIM II is somewhat controversial as a predictor of SWP yields and impacts. The nearly complete reliance by DWR on the CALSIM analytical approach is another reason for decoupling hydrology from project operations in FERC's analyses of baseline conditions and project impacts.

The Monterey Amendments include significant operational revisions to the SWP system that includes the Oroville Facilities. These operational opportunities will become more and more significant in the future as ways of managing the SWP system for maximum water supply benefit. As groundwater storage is developed outside the SWP service area, as carryover storage in reservoirs and groundwater banks is expanded, and as Table A deliveries increase from 2,000,000 acre-feet to 4,000,000 acre-feet, it is foreseeable that Oroville reservoir operations will be affected. The Monterey Amendments have been in place since 1995, and DWR expects them to continue throughout the new license term of the Oroville Facilities. The baseline for historic operations of Lake Oroville and the SWP should more accurately be broken into two periods: the pre-Monterey (pre-1995) period and the post-Monterey (1995 to present) period to better understand what is actually being proposed by DWR in the new license.

Additional and more clearly presented information would enable the reader to better understand baseline relationships between inflows, outflows, lake levels, and specific project operations criteria. An accurate understanding of the interplay between these factors throughout the baseline period is crucial for understanding the proposed license and future project impacts.

Proposed Action/Staff Alternative

Without enforceable license conditions, assertions about future reservoir operations cannot be relied upon by the public or by decision-makers. FERC should revise the DEIS to include specific license conditions that ensure that Lake Oroville will be operated in the future as it has been operated in the past under two possible operational scenarios: the pre-1995 period or the 1995 to 2005 period. Specific license conditions will ensure that in the event of conflicts between minimum lake levels and water deliveries, for example, the license conditions on minimum lake levels will control reservoir operations.

In the current Staff Alternative, it appears that discretion is given entirely to DWR as to how best to balance minimum lake levels in Oroville and water deliveries from Oroville to downstream SWP contractors. FERC should require DWR to disclose "historic operations" in more detail, by water year type, and disclose the environmental impacts of the changed Oroville reservoir operations since1995. Only with specific information about historic operations including the recent operational changes can FERC determine how to mitigate negative environmental effects through enforceable license conditions or PM&Es.

As shown by the following examples, enforceable license conditions on reservoir operations are necessary for protecting environmental values because there is considerable confusion even among knowledgeable parties about how DWR actually operates the SWP and the Oroville Facilities.

- DWR's final recreation study for the EIS entitled "Assessment of the Relationship of Project Operations and Recreation" (May 2004), states on page 5-24: "This analysis (of recreational impacts associated with summer lake levels) assumes that reservoir elevations in the future will vary within a range and frequency similar to that seen from 1990 to 2002."

- During the period from 1990 to 2002, it appears from Figure 5 on page 22 of the DEIS that Lake Oroville elevations were at or dropped below the 750-foot elevation nine times.
- During the period from 1970 to 1990, the lake dropped below the 750-foot elevation four times.
- SWP deliveries exceeded 2,000,000 acre-feet in five of the years between 1990 and 2001, compared to only four times in the 20 years from 1970 to 1990.

Changes in water supply operations have occurred at Lake Oroville, especially since 1995, as part of the Bay-Delta CALFED ROD assurances and through the increasing implementation of the 1995 Monterey Amendments to the SWP contracts. These recent operational changes at Oroville have also caused many environmental changes on the Feather River downstream to the Bay Delta Estuary. The operational changes that are now occurring at Oroville should be used to more accurately predict the impacts of future Oroville project operations on the Feather River, the Sacramento River, and the San Francisco Bay Delta. (For reference, 1990, 1991, and 1992 were classified as Critically Dry water years, 1993 was above normal, 1994 was dry, 1995 to 1999 were wet water years, 2000 was above normal 2001 was dry, 2002 was also dry, and 2003 was above normal.)

CALSIM modeling information and DWR's assertions comprise the majority of the information presented in the DEIS. Only Figures 4 and 5 of the DEIS actually display a historic record of Oroville reservoir operations and provide the clearest picture of future Oroville operations. Using Figure 5 it could be inferred that in the future Oroville could be operated so that:

- Minimum lake levels will not fall below the lowest lake elevations of just under the 670-foot elevation and just below 1,000,000 acre-feet of storage (which occurred in years 1977 and 1990) more than twice over the next 30 years.
- The Oroville lake levels would not fall below the 750-foot elevation and 1,500,000 acre-foot storage level more than 10 times in 30 years.
- Oroville lake levels would remain above 2,000,000 acre-feet for over half of the new license period.
- Uncontrolled spills of floodwaters would not occur more frequently than five times over the next license period. (Major past spill events are displayed on page 75 of the DEIS, and occurred in years 1970, 1980, 1986, 1995, and 1996).

Figure 5 provides somewhat of a factual basis for developing license conditions that ensure that Oroville will be operated within specific storage, spill, and release parameters in the future. However, it seems from a closer examination of the inflow hydrology (using DWR water year classification information and the DEIS Figure 4 and 5 information) that Oroville reservoir operations extend drought levels in the lake through the next normal to wet year. This means that drought conditions continue at least one year longer in Oroville as a result of operational factors.

Operational factors such as high water deliveries to drought-short water contractors downstream are controllable factors by the licensee. Therefore, if continuing the historic reservoir operations violates water temperature standards for salmonids downstream of the project, a license condition should be developed by FERC that ensures that water quality standards will be met downstream of Oroville through maintaining adequate cold water reserves in Lake Oroville – especially during and the year following droughts. FERC has the authority to ensure the protection coldwater reserves in the lake through license conditions for minimum lake levels during and following dry and critically dry years. Through license conditions that specify minimum lake levels, adequate cold water reserves in Lake Oroville would be maintained throughout the new license period in order to protect the cold water fishery both within the lake and downstream.

Exhaustion of the coldwater reserves in Lake Oroville due to drought and post-drought project operations would need to be prevented through license conditions or fully mitigated. Without adequate protection for coldwater reserves in the Oroville reservoir, upstream reservoirs in Plumas County are vulnerable to emergency draw-downs. In the event of a situation such as the Klamath River fish kill repeating below Oroville dam, there is a very real possibility of an emergency appropriation of the one-half million acre-feet of cold water sitting in upstream reservoirs in Plumas County. Poor planning on DWR's part should not be permitted to shift project impacts elsewhere in such a manner.

CLIMATE CHANGE ALTERNATIVE

The first new alternative that should be included in the EIS would incorporate and fully analyze DWR's recently published information on climate change impacts on SWP storage and delivery capabilities. See Progress on Incorporating Climate Change Into Management of California's Water Resources, Technical Memorandum Report (July 2006) (incorporated herein by this reference).

Lake Oroville drains the Upper Feather River Basin. According to the DWR report, the Upper Feather River Basin, as the lowest elevation watershed in the Sierra Nevada Range, will be especially affected by climate change-induced variability in precipitation and runoff. Inflows to Lake Oroville will change, possibly dramatically, over the next 30 years. It is reasonable to anticipate that operations at Lake Oroville may be affected by changed inflows and watershed hydrology.

DWR's own analysis of plausible inflow changes for Oroville under moderate and foreseeable climate change conditions suggests that historic operations may not be sufficient to maintain the cold water fishery in the lake or provide needed downstream fish flow under changed climate conditions. As the following quotes from the document show, this future hardly sounds like business as usual:

> (1) As discussed in Section 2-5, climate change is expected to cause more precipitation in the form of rain rather than snow, reductions in water storage in annual snow-pack, earlier snowmelt and sea level rise. Each of these factors could present significant reservoir management challenges particularly for reservoirs in

the Sierra foothills. These reservoirs will likely experience changes in the rate and timing of inflow. Changes in reservoir operations and reduced annual storage in snow-pack could result in less water being available in the summer and fall to meet Delta outflow and salinity control requirements. (p.2-60.) Increased use of reservoir storage and thermal control devices will be required for controlling aquatic habitat temperatures. (p. 2-56.)

(2.) Figure 4-12 shows that Oroville is likely to have available capacity to capture increased inflows in December, January and February in all four climate change scenarios. Only in March does the flood control frequency rise above 50 percent for three of the climate change scenarios. (pp. 4-24 to 4-27.) As can be seen from figure 6-25, there is a significant increase in driest runoff volume associated with higher elevations for snow pack due to the increased contributing area of the watershed. The more than doubling of the peak runoff associated with a 5 degree C increase in mean atmospheric temperature would cause significant changes in the return period of peak runoff associated with a specific rainfall event. (p. 6-32).

(3) In the climate change scenarios presented in this report, one significant issue was the critical shortages of water in reservoirs north of the delta that occurred when present operating rules were applied. Future directions would include examining *increases* in carryover storage in Shasta and Oroville reservoirs to prevent loss of operations control of the Sacramento and Feather rivers during droughts. Corresponding reductions to delivery allocations would be required. If those measures weren't sufficient to provide a reliable water supply, additional measures would be investigated such as a rebalancing of water sharing mechanisms established in the Coordinated Operations Agreement. System flexibility should be sought to mitigate climate change effects on SWP and CVP deliveries. In the current analysis flood control spaces were left unchanged. In the future, it is planned to vary flood control space with different climate change scenarios. Furthermore refined flood forecasting might allow more runoff to be captured in the early spring than is otherwise possible now. Also operational rules and regulations will have to be reassessed given a changed hydrology. (p.8-1.)

Information on climate change is readily available to FERC. Based on DWR's own analysis, climate change is a potentially significant impact on future operations of the Oroville Facilities. Therefore climate change impacts must be meaningfully integrated into the DEIS analysis of project alternatives and the mitigation of project impacts. Failure to do this analysis is a failure to follow NEPA and is an arbitrary and capricious exercise of authority under the Administrative Procedures Act.

DOUBLED EXPORTS ALTERNATIVE

The second new alternative would analyze the effects of project operations under a doubling of Delta exports. The expected doubling of water supply deliveries to SWP contractors south of the Delta by the year 2020 will likely have a significant effect on reservoir operations and lake levels at Lake Oroville. If a full alternative is not presented to analyze the impacts of doubling exports, the final EIS must disclose the evidence and reasoning behind the DEIS conclusion that Oroville operations will not change as SWP water deliveries double.

The proposed Doubled Exports Alternative would analyze reservoir responses to significantly increased SWP water supply deliveries to the Delta for export to water supply contractors over the next license period. Doubling water exports from Northern California has the potential to significantly affect Lake Oroville reservoir operations because Lake Oroville is the largest reservoir in the SWP system. It is reasonable to anticipate that increased water deliveries will come at least partially from SWP reservoir releases of stored water. Different release schedules and volumes from Oroville have affected and will affect coldwater fisheries and aquatic habitats downstream from Oroville

Oroville has a storage capacity of 3,558,000 acre-feet. San Luis Reservoir, the only other major facility in the SWP system, shares storage capacity with the federal Central Valley Project. The SWP's share of the San Luis Reservoir is 1,067,000 acre-feet. Together, these two reservoirs provide approximately 40 percent of the state and federal water supply storage in California that originates upstream of the Delta. A doubling of water deliveries to SWP contractors would necessarily affect Oroville operations.

DWR's "The State Water Project Delivery Reliability Report" is an important information source for a FERC analysis of reoperation alternatives for the Oroville Facilities. The report is readily available and is hereby incorporated by reference into the administrative record for this proceeding. The assurances provided by DWR in the report about the accuracy of DWR's water supply forecasting are under continuing litigation and are less certain today than the 2002 State Water Project Water Reliability report suggests. Critics of the report question many of the modeling assumptions that underlie DWR's estimates of water available for export from the Delta.

As Chart 7 indicates on page E-115 of the DWR report, modeled water deliveries are less sensitive to hydrology than actual water deliveries. Chart 6 on page E-114 compares actual and CALSIM modeled SWP deliveries. Actual SWP deliveries exceed 2 MAF only after 1986. Higher deliveries occur only in the dry period from 1987 to 1992 and in five of the nine years thereafter for a total of ten times. By comparison, CALSIM modeled deliveries exceed 2 MAF twenty times from 1978 to 2001.

Chart 2 on page E-110 ascribes some of the discrepancy between modeled and actual deliveries to different accounting methods for carryover storage in SWP reservoirs. The Monterey Amendments expand carryover storage, and under the Monterey Amendments carry-over water storage in Oroville becomes ever more difficult to model accurately.

On page E-161, DWR describes the sensitivity of reservoir storage information to constraints such as Delta pump take limits under the Endangered Species Act and to the State Water Resources Control Board's (SWRCB's) water rights and water quality regulations.

On Page E-166, DWR describes the magnitude of uncertainty associated with using actual deliveries and modeled simulations to forecast future reservoir operations in Oroville:

Modeled SWP demand for 1986, a wet year before the dry period, is 3,345 taf compared to the actual request of 2,364 taf. As a result of this higher model demand, modeled SWP storage at the beginning of the dry period is approximately 420 taf lower than the actual SWP storage. The modeled storage at the end of the dry period is essentially the same as the historical value. ....To adjust for the 420 taf difference in storage, 70 taf was added to the modeled delivery for each of the six years in the dry period. The adjustment raises the average model delivery for the dry period to 1,980 taf/yr, 50taf/yr lower than the historical average of 2030 taf/yr, as shown in Figure 4.

Figure 1 on page E-167 of the report shows Table A requests compared to the 2001 model study of SWP Table A demand. It is important to note that, after 1995, Table A demands and deliveries are the same in the model but are not the same in fact.

For years 2001, 2002, and 2003, Table A demands reach or exceed 4 MAF. In the DEIS, 2001 and 2002 are used in Table 14 on page 74 to depict Oroville reservoir storage. DWR notes on page 73 of the DEIS that "[t]his value is higher than calculated using historical USGS records because it reflects the current level of demand. DWR estimates the range as being from 613,000 acre-feet per year to 1,057,000 acre feet per year under current conditions.

The foregoing examples disclose how unreliable modeled estimates of modeled Table A water demands may be for predicting and analyzing the impacts of future reservoir operations both within and downstream of Lake Oroville. FERC should independently analyze and protect non-project water benefits within Lake Oroville, as well as upstream and downstream, through license conditions that specify lake levels under different hydrologic, carry-over storage, and delivery regimes.

CUMULATIVE EFFECTS ANALYSIS

The EIS must include an adequate analysis of cumulative effects from the combination of doubled water deliveries and intensifying climate change on fisheries, reservoir water levels, coldwater reserves and releases, and downstream flooding, for all water year types during the new license period. The analysis will help identify, prevent, or fully mitigate for significant redirected impacts, both upstream and downstream of the Oroville Reservoir, that could occur from changed reservoir operations in response to cumulative environmental effects.

The DEIS fails to take a hard look at cumulative effects associated with the effects of climate change in combination with increasing SWP water supply deliveries. The DEIS fails to take a hard look at the Oroville project as a piece of the SWP water supply project. The fate of fisheries in the Bay Delta and in the Sacramento and Feather Rivers downstream from Oroville are tied to operations of the Oroville facility.

The SWP project has an immense effect on the fisheries and environment of the Central Valley of California and most specifically on the Bay Delta Estuary, the largest estuary of the West Coast of the Americas. This project requires FERC to exercise its duty under NEPA and the FPA to independently review and, if necessary, revise, through license conditions, DWR's storage and reservoir operation criteria for the Oroville Facilities to protect below-project areas from more frequent uncontrolled flood releases and to retain adequate cold water reserves in Lake Oroville for maintaining coldwater fish habitat and water quality in the Lake and downstream under new and changing conditions. Pursuant to this standard, FERC must explore all issues relevant to the public interest. Typical (and sometimes competing) uses for a waterway include power generation, irrigation, flood control, navigation, fish and wildlife, municipal water supply, and recreation

In the Electric Consumers Protection Act (ECPA) of 1986, P.L. 99-495, 100 Stat. 1243 (Oct. 16, 1986) (codified at 16 U.S.C. § § 71a, *et seq.*), Congress amended Section 4(e) pf the FPA to require the Commission to give equal consideration to developmental and non-developmental values. In addition, FERC is mandated to ensure that any license issued is consistent with existing "Comprehensive Plans." It is implicit that in order to provide for "protection, mitigate of damage to, and enhancement of fish and wildlife...," that FERC must first evaluate environmental impacts in a broad sense. The FPA clearly distinguishes between the project boundaries and the environment affected by the project (action area). For instance, FERC's relicensing regulations at 18 CFR § 16.8(b)(i) require that the applicant provide detailed maps of the project boundaries, and at § 16.8(b)(iv) the applicant must additionally provide an identification of the environment affected, or to be affected, and proposed mitigation.

The FERC licensing regulations provide, at 18 CFR § 4.41(h)(2), that "[t]he [project] boundary must enclose only those lands necessary for operation and maintenance of the project *and for other project purposes*, such as recreation, shoreline control, *or protection of environmental resources*." FERC's regulations would not make these separate requirements of a description of the affected environment if the affected environment to be addressed by FERC is always the same as the project boundaries. By not looking outside the limited Oroville project boundary, FERC ignores impacts of the SWP outside of the project boundaries in violation of the FPA. For FERC to ignore the environment upstream or downstream of the actual project boundaries is an arbitrary and capricious exercise of authority and a failure to comply with the law.

In considering the relicensing of the Oroville Facilities, FERC must consider that this decision will affect all parts of the integrated SWP water supply system both upstream and downstream of the Oroville portion of the SWP. The relicensing of these facilities will impact the operations of upstream reservoirs within Plumas County, impact recreational opportunities along the Feather River and other downstream areas, determine the level of flood control for Marysville, Yuba City, and all other communities below the reservoir, determine habitat quality for all salmon runs in the Sacramento River, and impact species in the Bay Delta Estuary for the term of the new license.

Delivering water from the SWP is an energy-intensive exercise, particularly if that water then must also be pumped over the Tehachapi Mountains to Southern California. The SWP is already a net energy consumer and is the largest single consumer of energy in California. Energy production results in greenhouse gas emissions, possibly exacerbating climate change impacts to California. Reducing SWP energy use, and substituting greater use of conservation, recycling, and local supplies would vastly reduce the amount of energy California expends and greenhouse gases produced delivering water.

A properly prepared EIS should define the purpose of a project in a non-tautological manner and not define the purpose so narrowly that no real alternatives to the new operations of the SWP can be considered. Given the importance of this process, the Environmental Impact Report must be rewritten and re-circulated to agencies and the public to consider all impacts associated with the proposed operations of the Oroville Facilities.

Fisheries and Cumulative Effects

The DEIS does not adequately analyze proposed hydropower operations given the estimated results of global climate change. The DEIS analysis must be revised to include extensive data available that estimates impacts of climate change on California. DWR released "Progress on Incorporating Climate Change into Management of California's Water Resources" in July 2006. This report and others that were completed as part of the Governor's Climate Action Team indicate that climate change is likely to result in altered hydrology with larger, less frequent storms that will come earlier in the year. This will reduce water supply and result in greater need for flood management, and may result in degraded conditions for the environment, including warmer water for fish. The DEIS must explicitly disclose how the proposed project will exacerbate all environmental impacts that are estimated to occur under climate change. Specifically, the draft EIS must analyze the degree to which the proposed project will impact the availability of water, and specifically the availability of cold water for fisheries given the impacts of climate change.

Downstream releases from the Oroville Facilities, and the impacts of those releases, are modeled using CALSIM II, a computer model that has not been validated and has not been accepted by peer reviewers because it contains many known flaws that prevent it from accurately analyzing environmental impacts. Even CALSIM II modeling data, however, demonstrates that the proposed operation of Oroville for the next 50 years could have substantial adverse impact on conditions below Oroville. There are three minimum flow requirements imposed on Feather River releases. The CALSIM model shows that if flows on the Feather River exceed an average of 4,000 cfs in October or 2,500 cfs in November, then the following months (through March) must maintain at least the previous month's flow, minus 500 cfs. The only exception to this requirement is in the event of an October or November flood (expressed as Lake Oroville storage in zone 6), in which case no flow requirements are triggered for the following months. This can heavily impact the fishery below Oroville in what are often low flow months. The CALSIM model attempts to avoid this minimum flow requirement by placing a heavy penalty on flows above 4,000 cfs in October and 2,500 cfs in November.

The CALSIM model also has a minimum instream flow requirement set for the reach of the Feather River between Thermalito and Verona that varies between 750 to 1,850 cfs depending on the month and the water year. This modeled flow release is not the same as the proposed flow releases analyzed in the DEIS and can substantially mislead FERC and public reviewers as to expected environmental impacts from granting this license. Finally, between April and September, according to the model, Lake Oroville is called upon to provide 2,800 cfs in addition to diversions along the Feather River, shown in the CALSIM-II schematic as D7A, D7B, D206A, and D206B. Yuba River inflows count toward this requirement. Additionally, the instream flow requirement here is constrained such that the sum of the diversions and instream flow requirement will not exceed the monthly inflow to Oroville Dam. The implication from reviewing this data is that maintaining reservoir levels for water supply is a higher priority than the satisfaction of downstream environmental flows.

Use of the CALSIM model could result in the DEIS underestimating environmental impacts from proposed Oroville operations on downstream fisheries and water quality. This is important given that the EIS has not fully analyzed the downstream impacts of the proposed Oroville operations in light of the new information from studies conducted as part of the Interagency Ecological Program's Pelagic Organism Decline (POD) research. Kimmerer (2002) showed that water project operations of the SWP and the integrated CVP have resulted in lower winter/spring inflow and higher summer inflow to the Delta. As noted previously, the actions by the CALFED implementing agencies, including DWR, have restored some spring inflow, but have also increased summer inflows to meet increasing summer export demands, as is proposed in this license. This shift was implemented based on the assumption that it would be more protective to sensitive early life stages of key estuarine fishes and invertebrates. However, it is possible that high exports from the SWP project during summer-winter months has unanticipated food web effects by exporting biomass that would otherwise support the estuarine food web. Other possible mechanisms include increased entrainment of fishes during the summer-winter months because of changes in SWP water operations, or a reduction in habitat quality downstream (e.g. less area of the appropriate salinity). Total annual exports have continued to increase from the SWP operations. It is also possible that the total volume diverted on an annual basis influences estuarine productivity (Livingston et al.1997, Jassby et al 2002.)

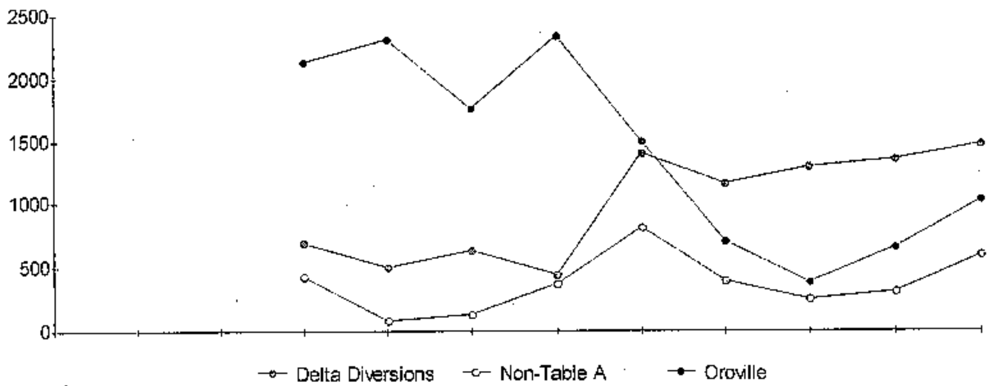
Lake Oroville water release changes from historical operations will affect waters entering the Bay Delta Estuary and will facilitate water operation that could be harmful to pelagic fisheries. Therefore, the EIS must address the degree to which the proposed project will contribute to reduced freshwater flows in the winter and spring and changes in the timing and temperature of flows to the lower Feather River, the Sacramento River and the Bay Delta Estuary, salinity changes in the Delta, and negative impacts resulting from such changes on fisheries. This assessment should include an analysis of the latest research from William A. Bennett of the Center for Watershed Sciences & Bodega Marine Laboratory, Pete Smith of the USGS, Lenny F. Grimaldo of the DWR, and Bruce Herbold of the US EPA, including findings presented at the October 2006 California Bay Delta Authority Science Conference and findings from the Review Panel Report San Francisco Estuary Sacramento San Joaquin Delta Interagency Ecological Program On Pelagic Organism Decline from May 24, 2006. In particular, lake level fluctuations that facilitate changed conditions in the Delta during winter and summer must be analyzed and impacts must be avoided or mitigated to the extent feasible.

Arve Sjovold, a board member of Water for California, has conducted analyses of recent SWP pumping regimes and the corresponding releases from Oroville Dam and has compiled the following table to verify the change in winter-time (DJFM) operations of the SWP since 2000.

State Water Project Operations

Water Year	Delta Diversions Sum (D,J,F,M) TAF	Non-Table A Diversions TAF	Oroville Releases (D,J,F,M) TAF	8-River Index (D,J,F,M) TAF
1996	696	434	2130	12970
1997	508	84	2308	17340
1998	638	134	1754	17740
1999	448	375	2335	10860
2000	1395	809	1495	12120
2001	1155	393	706	4760
2002	1286	249	385	9250
2003	1348	310	657	10810
2004	1473	604	1032	?

SWP Operations 1996-2004



The change in ratio of Oroville releases to DWR's Bay-Delta pumping has occurred during the same period that the pelagic fish and other organisms in the Delta have dramatically declined. State and Federal agencies studying this decline have indicated that changed winter-time water project operations have contributed to increased mortality of important species in the Delta since 2000. State and federal agencies have also stated that water project operations, including the SWP operation, could be a primary contributor to the fisheries decline in the Delta According to a declaration from Dan Odenweller in a recent California endangered species case, dramatic increases in winter CVP and SWP salvage occurred contemporaneously with recent declines in several pelagic fish species. These unexpected increases in salvage density coincide with the steep decline of pelagic fishes in 2002. The state and federal interagency team investigated the pelagic decline in the Bay-Delta has formulated a Winter Adult Entrainment Hypothesis that posits that these events are causally linked. Evidence for the hypothesis includes:

1. There appears to have been a step increase in salvage density of adult delta smelt, threadfin shad and longfin smelt between 2001 and 2002. This increase is consistent with recent-year changes in winter water export operations.
2. There appears to have been a step decrease in the Fall Midwater Trawl indices of adult delta smelt, threadfin shad, and longfin smelt between 2001 and 2002.
3. Winter exports from the CVP and SWP have increased since the late 1990s.

Before issuing a new license for the Oroville Facilities, FERC must fully analyze whether the proposed project will exacerbate downstream fishery impacts. The DEIS must be revised to fully evaluate whether proposed project operations will inhibit the restoration and full recovery of endangered species, including salmon, steelhead and Delta smelt, as well as the ecosystem of the Feather River, the Yuba River, the Sacramento River and the San Francisco Bay-Delta. Specifically, the EIS must disclose whether the proposed project will prevent achievement of restoration goals established in the Central Valley Project Improvement Act and the joint state and federal CALFED program as well as meet Clean Water Act standards below Oroville Reservoir.

Section 18 of the FPA states that FERC shall require construction, maintenance, and operation by a licensee of such fishways as the Secretaries of Commerce or the Interior may prescribe. Section 2.3 of the Settlement Offer requests that FERC include in the new license a reservation of the Secretary of the Interior's authority to require the construction, operation, and maintenance of fishways. Consistent with FERC practice, an article in each of the licenses includes the requested reservation. The inclusion of the fishways reservation in the proposed license does not mean that FERC can avoid the upstream impacts of granting a license without a "hard look" at the impacts of the Oroville project on upstream ecological and fishery values.

The North Fork Feather River itself was once considered "one of the nation's top five blue ribbon rainbow trout fisheries." (Cal Trout 2005.) Fishermen from as far away as San Francisco once boarded a train known as the "Rainbow Special" to fish and enjoy the anadromous fish of the Feather River. (CSPA 2005.) Hydroelectric and water supply dams and diversions have been identified by government studies as the single biggest cause of fish declines in California. (Moyle and Williams, 1990.)

The Sierra Nevada Ecosystem Project, an extensive investigation chartered by the United States Congress, came to the following conclusions:

> In streams on the west side of the Sierra Nevada, most fish assemblages lost major components, mainly chinook salmon and other anadromous fishes, following the construction of dams in the nineteenth and early twentieth centuries... The disruption of these communities is continuing...In terms of numbers and biomass, [salmonids] were among the most abundant fish in the streams. They were consequently a major source of energy for stream ecosystems, a major food for the Native Americans, and, after the Euro-American invasion in the nineteenth century, a mainstay of commercial fisheries. In recent years, their continuing decline has been a source of major conflict among various interest groups... (UC Davis 1996)

Under the FPA, FERC-licensed dam owners bear a proportional responsibility for protecting, mitigating, and enhancing impacts to these fishes. Hydroelectric and water supply dams account for a loss of roughly 95 percent of the original spawning habitat in the Central Valley for salmon and steelhead. (Yoshiyama et. al 2001) "Salmon originally ascended a considerable distance in the Feather River system, particularly the spring run which spawned in the higher streams and headwaters. They went … up along the entire length of the North Fork Feather River through the area now covered by Lake Almanor and into the surrounding tributary streams (>4,200 ft. elev.). Early correspondence sent to the DFG state that large numbers of spring-run fish ('in the thousands') entered the North Fork… Flows from the many springs that fed the Lake Almanor area, together with stream-flows from farther up the North Fork, undoubtedly were sufficient for salmon to have ascended through the lakebed area and up the North Fork another six miles or more.

In a newspaper article more than a century ago, Dr. J.H.C. Bonte wrote of salmon angling: "They are caught with hook and bait now along the Sacramento river above Knight's Landing, and in the Feather River not far below Lassen's Peak…Young salmon are frequently caught in Big Meadows, Plumas County, and older ones weighing eight and ten pounds, are also taken though not very often." (Sacramento Union, 24 December 1881.)

The applicants for licenses on the Feather River, including DWR and PG&E, have constructed dams without fish ladders or screens in known historic habitats of anadromous fishes. The only protection, mitigation, or enhancement measures were fish water releases of approximately 5 percent of the lowest known historic flow and partial maintenance of a pre-existing fish ladder on Big Bend. In working on the Feather River relicensing projects, it has become apparent that NOAA Fisheries has determined that anadromous fish passage to certain reaches of the North Fork Feather River may be appropriate and feasible – although NOAA's initial fish passage prescription has been withdrawn for the time being.

Plumas County has concerns that when the experimental 15-year salmon and steelhead relocation program proposed for the DWR and PG&E expires without accomplishing its intent to protect Feather River salmon and steelhead, the fish passage issue will be reopened. Plumas County is interested in reserving all rights to consultation, participation, and compensation in the FERC license reopening process for fish passage for Project 2100.

Plumas did not sign the Settlement Agreement for Project 2100 in part out of skepticism about the proposed salmon relocation program and over concerns about how the Settlement Agreement affects Plumas' standing as the County with much to gain or lose from the reopening of the fish passage issue. The EIS needs to be specific about how consultation with Plumas County and the resolution of Plumas County's concerns relating to fish passage impacts will be ascertained and addressed when the fish passage issue is reopened during the new license period. As the County's experience with FERC projects 2107 and 2105 indicates, reservoir lake levels are vulnerable to instream coldwater fishery needs. Plumas needs assurances through license conditions in Project 2100 that the failure to address cumulative downstream effects of operation of the Oroville Facilities does not simply redirect mitigation and undue burdens upstream to FERC Projects 2107, 1962 and 2105 or to other areas within Plumas and Butte Counties.

The proper venue for the resolution of cumulative effects of fishery declines related to the operation of the SWP is in two DWR program areas that need to be analyzed together for their cumulative effects: (1) the Oroville fish passage program and settlement agreement program and (2) the Biological Opinion for OCAP in the Bay-Delta Estuary. As recommended by independent science panels, the only effective course of action is an integrated analytical approach to preserving salmon fish stocks in the Delta and Central Valley.

The United States Fish and Wildlife Service and the NOAA Fisheries have both reinitiated consultation on the Biological Opinions for the OCAP, which is the operational criteria rules for the operation of Oroville Reservoir in the integrated system of the Central Valley of California. Since operation of the Oroville facilities are included in the OCAP Biological Opinions, further analysis of the proposed Oroville operations and preparation of subsequent drafts of the EIS should be delayed until these Biological Opinions are completed and the findings of those documents have been incorporated into the environmental analysis for this proceeding.

FERC should include in the EIS information from the report, incorporated here by this reference, of the Technical Review Panel convened by the CALFED Bay-Delta Program to review the Biological Opinion for the OCAP. This OCAP BO contains necessary information to enable the lawful relicensing of the Oroville Facilities, including assessment of the effects of the continued operations of the CVP and SWP on listed Chinook salmon and steelhead in the Sacramento River and its tributaries, including the Feather River.

The Technical Review Panel was unanimous in its finding that the scientific information used in the BO is not the best available science. (Technical Peer Review, p. 2.) As salient examples, NOAA Fisheries, as well as the DEIS itself, ignored the potential effects of climate change in their analyses in the BO, and NOAA Fisheries used a temperature-mortality model (LSalmon-2) that does not produce credible estimates of temperature-induced mortality. Other important factors, such as variable ocean conditions or the risks associated with hatchery-released fish, are described in parts of the BO, but how these factors were related to the conclusions regarding lack of jeopardy from project operations were unclear to the review panel.

The review panel identified three overarching issues which, if addressed, would improve the presentation of the analyses in the BO. These issues need to be addressed, as well as the fifteen specifically identified flaws, before using the NOAA Fisheries' opinion of no jeopardy for the Oroville Facilities. Specifically, the review panel found that the BO would have benefited:

1. From a clearly articulated conceptual model
2. From an analytical framework (based on the conceptual model) for the various data analyses, statistical models, and analytical tools that were used
3. By placing its analyses in the context of an explicitly defined life cycle approach.

The Sacramento River system, of which the Feather River is a major part, and the associated water resource facilities, forms a very large and complex set of reservoirs and river reaches, which ultimately flow into the Pacific Ocean through the Delta. Because the system is so complex, an analysis of the effects of project operations, such as those examined in the BO and the DEIS, would benefit from an explicit (Cumulative Effects) analytical framework. An explicitly described (Cumulative Effects) analytical framework would characterize the various components of the system and, to the extent practicable, permit important processes and impacts to be quantified. The basis for the analytical framework is a clearly articulated conceptual framework and a life cycle approach. The analytical framework itself consists of the models, analytical tools, and assumptions used in the assessment, and how these models and tools relate to each other in terms of shared information and overlapping assumptions.

An explicitly defined (Cumulative Effects) analytical framework would assist in: (a) ensuring the proper questions are assessed using appropriately configured models, (b) determining that the temporal and spatial resolution of the various models is consistent with the scales of the problem, (c) defining the data gaps, and overlapping assumptions and parameter values among the various models, (d) ensuring analyses are performed in a consistent manner using the same information pool, and that competing assumptions are clearly articulated, (e) providing a framework for incorporating uncertainty into calculations and for propagating the uncertainty through the models to allow assessment of overall risk and (f) ensuring documentation of the various models and analyses, and accurate conveyance of assumptions and results to decision makers.

Extensive field data collection efforts related to water temperature have been performed in the Sacramento River system. The advent of inexpensive remote logging thermistors has made available sub-daily temperature (e.g., hourly) observations in critical river reaches where salmon and steelhead reside. Furthermore, models that operate on sub-daily time steps have been applied to the Sacramento River (Deas et al 1997; Watercourse 2002), Clear Creek (Fellos 2000), the Feather River (Cook and Orlob 2000; Deas et al. 1997), and the Stanislaus River and lower San Joaquin River (AD and RMA 2002). The review panel realizes that use of these models is not simple and the models have not been used to date to address specific BO issues. However, the panel believed that examination of existing field data and modeling results may offer appreciable insight about short term variability (e.g., daily, sub-daily) in temperature at important locations in the system. These models need to be used to determine what the real environmental effects on fish and wildlife will be under the new operations scenario proposed for the new Oroville license.

The Oroville Facilities are operated by DWR as part of the State Water Project. The State Water Project's compliance with the California Endangered Species Act (CESA) at the Delta pumps is currently under consideration in a lawsuit in Alameda County Superior Court. The analysis of the downstream fisheries effects of the operation of the SWP integrated project should be delayed until the court decides whether the operation of the SWP is in compliance with California law. Should the court find that the SWP is not in compliance, the EIS analysis should be delayed until compliance has been achieved.

Additionally, the EIS should include comprehensive evaluation of potential reintroduction of fish species in the South Feather (FERC Project No. 2088) and DeSabla-Centerville (FERC Project No. 803) relicensing proceedings and not piecemeal these connected project reviews. The prescriptions for these and all Feather River project should work in concert to address the recovery of salmon and steelhead..

The California Advisory Committee on Salmon and Steelhead Trout was created in 1983 to develop a strategy for the conservation and restoration of salmon and steelhead in California. The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 was signed by the Governor of California to implement the committee's recommendations, which included doubling the natural production of salmon and steelhead from those that existed in 1988. The Steelhead Restoration and Management Plan for California (CDFG 1996) summarized this Act as follows:

> Proper salmon and steelhead resource management requires maintaining adequate levels of natural, as compared to hatchery, spawning and rearing. Reliance upon hatchery production of salmon and steelhead is at or near the maximum percentage that it should occupy in the mix of natural and artificial hatchery production in the State. If both hatchery production and natural production are feasible alternatives for increasing salmon and steelhead numbers in specific situations, preference shall be given to natural production.

Central Valley spring-run Chinook salmon and Central Valley steelhead have been nearly eliminated on several Central Valley Rivers, including the Feather River. On the Feather River, these species have been heavily impacted by dam construction. However, populations still exist and the Endangered Species Act requires actions that will protect them.

Meyer Resources Inc. (1988) conducted an analysis of the economic benefits that would result from doubling California's salmon and steelhead stocks as legislated. The Steelhead Restoration and Management Plan for California (1996) estimates that the net annual economic benefit would for the Sacramento and San Joaquin rivers would be $101.4 million (Table 2). A large portion of this benefit could be assigned to the Feather River, given its 1843 status as "tributary to the Sacramento and still richer in salmon" (Van Sicklen 1945, as quoted in Yoshiyama et al. 2001.)

Water Rights, Groundwater and Cumulative Effects

The DEIS should be revised to fully analyze and disclose the impacts of the Oroville Facilities on Sacramento Valley water users, including any potential impacts to groundwater levels and groundwater replenishment. The very important and extensive groundwater aquifers under the Sacramento Valley are replenished by the Feather River and other Central Valley Rivers. The natural recharge areas for these aquifers are dependent on the surface water regimes of the Feather River and other Central Valley streams. Most of the riparian habitat of the Central Valley is dependent upon river flow that is reflective of the natural stream flow pattern that existed before the building of Oroville Dam.

Impacts from Other DWR Actions

The DEIS must fully analyze the impact of Oroville Facilities in light of the cumulative impacts of all projects that are currently being pursued by the DWR. Specifically, the environmental analysis must include impacts to the water quality, fisheries and recreation resulting from the cumulative impacts of the South Delta Improvement Project, the California Aqueduct/Delta Mendota Canal Intertie, water acquisitions for the Environmental Water Account, projects proposed under the Operations Criteria and Plan, and similar projects that will affect the resources of the Feather River, the Sacramento River, and the Bay Delta Estuary. Many of these projects will have significant impacts on the environmental resources of the Bay Delta and its upstream reservoirs.

Flooding and Cumulative Effects

Before approving a project that will guide Oroville operations for another 30 to 50 years, FERC must ensure that water operations will not imperil the lives of people now living downstream. The DEIS must be revised to incorporate an analysis of the likely changes in reservoir operations that will be necessary to maintain, at a minimum, the current level of flood protection for the communities downstream of the Oroville facilities. Furthermore, the DEIS must fully disclose whether this project will exacerbate flood impacts likely to occur under climate change and disclose whether the proposed project will limit or reduce the flood protect available to downstream communities given estimated hydrology for the next 50 years.

Recent events repeatedly have raised alarms about the State's responsibility and liability for the Central Valley flood management system. On a sunny June day in 2004, a private levee in the Sacramento-San Joaquin Delta unexpectedly collapsed and flooded a Delta island, shutting down a State highway, a major railroad line, and State Water Project pumps that ordinarily move much of Southern California's drinking water south. The State alone spent $45 million to repair the levee and pump out the island. Last summer, the Legislature approved $500 million in settlements of claims against the State for failed levees in the 1986 and 1997 floods. Finally, this fall, Hurricane Katrina hit the Gulf Coast, levees failed, New Orleans flooded, and more than a thousand people died. Newspaper reports and editorials emphasized the obvious comparisons between New Orleans and Central Valley cities like Sacramento, Yuba City, and Marysville.

In 2003, a State appeals court highlighted the liability risks the State faces from failed levees. See Paterno v. State (2003) 113 Cal.App.4th 998. The *Paterno* court held the State liable for failure of a levee generally operated and maintained by a local levee maintenance district. The State's liability was substantial because homes and a shopping center were built behind the levee and suffered from the resulting flood. The *Paterno* decision – and recent events – set the stage for hearings to establish the broad outlines of the flood liability challenges facing the State of California.

The State – through the Reclamation Board – shares in the costs of construction, assumes responsibility for the operation and maintenance of the facilities, and holds the Federal Government harmless from liability. For Central Valley flood management projects, the Reclamation Board delegates operation and maintenance to the Department of Water Resources or local flood agencies. DWR's primary responsibilities lie in the Sacramento Valley, while primarily local agencies take responsibility in the San Joaquin Valley.

The Reclamation Board has the legal responsibility for oversight of the entire Central Valley flood management system, although the responsibility resides administratively within DWR. The Department of Water Resources also plays a significant role in California's flood management system, with staff inspecting and maintaining many miles of levees and other flood management facilities. DWR inspects and evaluates the maintenance of all of the State's federally designated project levees and channels. While most project levees are maintained by local agencies, DWR may perform the levee maintenance where the levees provide broad system benefits and local interests are unable to perform satisfactory maintenance. DWR also maintains the Sacramento River system channels (e.g. dredging), while local agencies maintain the San Joaquin River system channels. DWR's Division of Flood Management describes its mission as follows:

> The mission of the Division of Flood Management is to prevent loss of life and reduce property damage caused by floods, to facilitate recovery efforts following any natural disaster, and to carry out its public safety responsibilities in ways that preserve and restore the environment.

In recent years, both federal and state agencies have prepared reports emphasizing the deteriorating conditions of the Central Valley flood management system. In January 2005, DWR issued a "White Paper" regarding flood management, noting that powerful flood flows have eroded levees and deferred maintenance has not caught up. In addition, the White Paper observed that the Central Valley's growing population is pushing new housing developments and job centers into areas that are particularly vulnerable to flooding. DWR estimated the following risks from flood damage:

- 500,000 people in floodplains
- 2 million acres of cultivated acreage
- 200,000 structures with a value of $47 billion

The DWR White Paper concludes: "These factors have created a ticking time-bomb for flood management in California."

In December 2002, the Army Corps of Engineers issued an "Interim Report" on its Sacramento and San Joaquin River Basins Comprehensive Study, which arose out of the devastation from the 1997 floods. In assessing the existing flood management system, the Corps identified the following issues:

- reduced flood conveyance capacity, due to reduced flow area (from sediment, vegetation growth and encroaching development), poor levee foundation conditions, deteriorating levees, and subsidence.
- "choke points" created by infrastructure development (e.g. bridges)
- substantial reliance on Sacramento Valley bypass system, with reduced bypass capacity

Alternative be supported through the PM&Es for Project 2100 – either independently by DWR or as part of a joint mitigation program with PG&E (as has been undertaken by both entities to apportion responsibility for restoring anadromous fish). The proposed program was presented in comments on the Draft EIS for the Project 2105 reclicensing, and those comments are incorporated herein by this reference (FERC accession number 20051219-5030).

Conclusion

Thank you for considering the comments of Plumas County and Plumas County Flood Control and Water Conservation District.

Respectfully submitted,

/s/ Brian L. Morris

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cc **P-2100 Service List**

Attachment B

Supplement to Watershed Restoration and Improvement Alternative

The information presented below supplements the Watershed Restoration and Improvement Alternative for water temperature moderation that was presented by Plumas County in the Project 2105 NEPA and CEQA proceedings, which was filed with FERC on December 19, 2005, accession number 20051219-5030. The supplemental information relates to water temperature benefits of actions proposed in that alternative and was developed for submission to the California State Water Resources Control Board in other proceedings, responding to questions raised by the State Board.

In addition to the data presented below, further studies are now planned through a grant from CALFED to refine the preliminary estimates of the potential for summer stream temperature moderation and flood attenuation effects in the Feather River Canyon due to upstream watershed improvements. The "Indian Creek Watershed Temperature and Flood Integrated Monitoring and Modeling Study," summarized below, is expected to be funded by October.

Indian Creek Watershed Temperature and Flood Integrated Monitoring and Modeling Study

The Watershed Environmental Hydrology (WEHY) model, together with local monitoring, will be utilized to assess the cumulative affects of localized restoration activities in the 477,000-acre Indian Creek watershed in the Upper Feather River Basin. The project will be able to evaluate the impact of restoration activities at upstream regions (Last Chance Creek, Red Clover Creek, Ward Creek, Hosselkus Creek, and Clarks Creek) of the Indian Creek watershed on the downstream sections of the watershed during historical critical wet and dry periods in terms of river flow, groundwater, soil water, evapotranspiration, and water quality (sediment, nutrients, and stream water temperature), using the existing reconstructed hydroclimate input data over the watershed. The project will also identify potential restoration areas through identification of all source areas within the watershed for the production of stream and groundwater flows and interactions, stream temperature impairments and environmental substances (sediment and nutrients).

Since restoration projects are already being performed in the upland 120-square-mile Red Clover Creek and 100-square-mile Last Chance Creek sub-basins of the 750-square-mile Indian Creek watershed, it is important to quantify the impact of these restoration activities on the whole Indian Creek watershed. The Watershed Environmental Hydrology (WEHY) model has already been applied to the Last Chance Creek watershed, a sub-basin of the Indian Creek watershed. One of the findings of the completed project is that in the Last Chance Creek watershed flood peaks were reduced in magnitude and baseflow releases from the watershed during the dry months increased after restoration. Also, it was shown that the annual sediment production at Doyle Crossing (at watershed outlet) decreased as a result of restoration. It was demonstrated that the WEHY model could identify the source areas for flow and sediment production in the project watershed. Such identification is useful for the selection of the most effective sites for further restoration activities. The model is capable of identifying the source areas (for sediment, nutrients, any groundwater recharge, and surface flow), and the areas of high water temperature. Thereby, it can also be used for effective restoration planning. The results of this work were presented at the 2005 NPS conference and are available on request.

In order to broaden existing watershed partnerships (as directed by the recently adopted Integrated Regional Water Management Plan for the Upper Feather River Basin) that help to balance the beneficial uses for the NFFR identified in the RWQCB Central Valley Basin Plan and that reduce conflicts between water users, this proposal develops a stream temperatures assessment modeling tool that can be used to foster sustainable watershed improvement strategies in the Indian Creek subwatershed of the temperature-impaired East Branch North Fork of the Feather River. The East Branch is the hottest part of the NFFR system and the Indian Creek watershed is the hottest part of the East Branch. The NFFR below Lake Almanor has recently been proposed for 303(d) listing for temperature impairment by the SWRCB. Beneficial uses of the NFFR designated in the Basin Plan include a cold water fishery, agricultural and municipal water supplies, hydroelectric generation, and water based recreation.

Once calibrated and validated over the Indian Creek watershed, the WEHY model will be customized for the Indian Creek watershed (IC-WEHY model) in order to become a tool for resource management for the local, state and federal agencies active in the watershed. The hydroclimate data for the historical period 1982-1993 that include the critical wet and dry periods and calibration/validation period 2000-2005 have already been reconstructed during the completed Last Chance Creek project and are available for use in the Indian Creek Watershed project, reducing project costs.

The Feather River Coordinated Resource Management (FRCRM) Watershed Monitoring Program (SWRCB Agreement # 00-115-150-0 with Plumas Corporation) provides monitored data for the calibration and validation of WEHY model (especially the water quality module) from 1999 to present over twelve existing monitoring locations within the Indian Creek watershed during the project. The FRCRM will gather additional monitoring data to verify the model's accuracy. Data already available under the existing FRCRM monitoring program include: 1999-2003 Stream Condition Inventory (SCI) data at seven sites, and continuous recording flow and temperature data at eight sites since 1999. The SCI data include channel cross-sections, slope, bank stability, water temperature, and water quality. Three existing DWR weather stations provide local weather data. Additional data that will be collected for this modeling effort include: sediment production during storm events, infrared water temperatures, supplemental water temperatures, and a 2007 repeat of the SCI protocol at the seven previously monitored sites.

In the interim, until the CALFED study is completed, information presented below represents the best current estimate of the downstream water quality benefits for FERC Projects 1962, 2105, and 2107 that could result from implementing watershed improvement projects upstream. The watershed restoration projects used for the analysis below are prioritized by the

Upper Feather River Integrated Regional Water Management Plan (IRWMP) for a recent application for Proposition 50, Chapter 8 implementation funds.

These projects, individually and collectively, improve both water supply and water quality for at least two designated beneficial uses, such as coldwater habitat, water-based recreation, and municipal or agricultural water supplies. The IRWMP signatories have provided the following implementation guidance for watershed improvement work since the adoption of the IRWMP.

"The watershed restoration program goal for the Upper Feather region is to enhance, sustain, and balance all designated beneficial uses of the Upper Feather River, now and into the future, for local and downstream beneficiaries. "

Priority watershed projects also reflect a prioritization of the IRWMP water improvement strategies themselves.

"There is a hierarchy to the strategies such that water quantity and water quality strategies, if implemented first, create a basis and direction for the other strategies. Implementing these two strategies accounts for about 85 percent of the objectives (10 of 12) in the Plan and about 85 percent of the actions (20 of 24). Thus the other goals can be achieved with little additional cost or effort if the strategies for water quality and quantity goals are implemented first and concurrently."

The projects analyzed below are consistent with IRWMP direction in the following ways:

- Projects measurably improve both water supply reliability and water quality, while also producing other quantifiable benefits such as flood attenuation and sediment reduction.

- Projects generate water quality and supply benefits at multiple scales- at the project scale, within the north state region, and for the state as a whole.

- Projects are equitable in the distribution of water supply and quality benefits. They produce water supply and quality benefits, not by diminishing, but rather, by improving, water supply and quality for other designated beneficial water uses.

- By achieving the IRWMP goals of multi-benefit, multi-scale and equitable projects, the benefits of the projects as a whole, are greater than the benefits of its parts.

The following table summarizes expected benefits by project. Following the table are detailed explanations of how the particular benefits were quantified.

Upper Feather River

Project Benefits

	Proposal Totals	Forest Water Quality	Genesee Valley Project	Sierra Valley Project	SVGMD – Wells	Quincy Wetlands Treatment	Last Chance – Phase II	Upper Middle Fork
Water Supply								
Third party water benefits								
Dry Year Baseflow Increase (af / Jun-Oct)	2,315	83	206	1,865			161	
Average Year Baseflow Increase (af / Jun-Oct)	2,323	83	205	1,865			170	
Water Quality								
Protect/restore/enhance beneficial uses								
June Stream Water Temp. (°F)	N/A		-5.04	-1.83			- 11.80	
July Stream Water Temp. (°F)	N/A		-8.58	-2.99			-11.66	
August Stream Water Temp. (°F)	N/A		-7.83	-3.34			-11.47	
Reduced Sediment Load (tons/year)	80,046	129	55,679	6,522			17,716	
Impaired water bodies/sensitive habitats								
Western Pond Turtle habitat (Acres)	123					37	86	
Dedicated in-stream flows (af-annually)	712		200	256				256
Avoided water treatment costs	$500K				$500K			
Avoided wastewater treatment costs	$1.5M					$1.5M		
Other Expected Benefits								
Ecosystem Restoration								
Restored Stream Channel (Miles)	50.3	38	2.5	0.8			9	
Restored Riparian Corridors (Acres)	2,889	2,432	400				57	
Rewatered Meadow Habitat (Acres)	1,692	300	350	300			742	
Other Restored Wetlands (Acres)	187			150		37		
Flood Control								
Flood Retention (af / Nov-Mar)	386						386	
Flood Peak Reduction (% of discharge)	N/A		-2.65	-9.36			-7.82	
Recreation and Public Access (Stream Miles)	41.3	38	2.5	.8				
Power Cost Savings and Production	$2.87M	$340K	$1.4M				$1.13M	
Research/Demonstration Value			•	•		•		•

Estimation of Project Effects

Water supply and water quality benefits are quantified where possible, by using monitoring information such as stream channel geometry, baseflow discharges and summer water temperatures. Modeling simulations are used to extrapolate monitoring information where monitoring information is not directly available. Ambient watershed monitoring data, project level effectiveness monitoring data from similar projects, and the Project Assessment and Evaluation Plans (PAEPs) for the proposed projects are used for the modeling-based estimations of project effects.

For example, multiple data sets were used to arrive at estimated effects for the proposed Last Chance Creek Phase II Project and the Genesee Valley Integrated Water Management Project. Data sources include:

- temperature data from the Last Chance Creek, Phase I project (LCC1),
- the recently published local study by Steven P. Loheide (*Quantify Stream-Aquifer Interactions*, attached in full at the end of this document)
- the California Hydrologic Research Lab LCC1 modeling study that was presented at the SWRCB's 2005 Non-Point Source Conference

In order to put the following benefits tables into perspective, it important to remember that the projects cover less than 0.2% of the total Upper Feather River watershed area (4,281.6 acres of 2,307,042 acres).

All projects analyzed below are located in the East Branch of the North Fork Feather River (EBNFFR). The EBNFFR is the main tributary upstream of the Feather River Canyon of the North Fork of the Feather River (NFFR). Before the hydroelectric projects were developed on the NFFR, the East Branch and Big Springs (now under Lake Almanor) were the sources of summer streamflows in the NFFR. The East Branch is still a major water source for hydro-electric projects in the NFFR during the winter precipitation season and during the spring snow melt/runoff season.

In June, the source water for hydroelectric generation shifts to stored water in Bucks Lake, Butt Lake, and Lake Almanor. Water releases from reservoirs dominates instream flows in the NFFR until the precipitation season and natural runoff resumes in late November and December.

The analysis estimates to what extent meadow and stream restoration in the EBNFFR can moderate stream temperatures entering the Feather River Canyon in June. <u>June is the critical period when NFFR hydroelectric operations shift from the EBNFFR to stored water.</u>

Plumas has an interest in maintaining lake levels in Almanor, Butt and Bucks reservoirs during the summer recreation season. Plumas has negotiated lake level agreements with the PG&E for FERC projects 2105 (Almanor) and 619 (Bucks) to maintain summer lake levels.

In the event of conflicts between summer lake levels and downstream NFFR flow and temperature requirements, Plumas has offered the Watershed Restoration and Improvement

Alterative as a partial solution to balancing beneficial water uses in the NFFR canyon in ways that do not redirect impacts to adjoining lakes, causing disproportionate economic and environmental burdens for Plumas County.

Water Supply Benefits

Physical change estimates were developed in the PAEPs for each project. The PAEP parameters and estimates for each project are based on "weight of evidence" of monitoring data from completed projects, expert judgment, and by using information from published studies (from within the region if possible).

The PAEP values, in turn, form the basis for physical attributes modeling analyses at the project scale and also downstream. The modeled simulations of physical changes are then used to compute economic benefits for the projects. Economic studies are used to establish economic values and for comparisons of methodological approaches to valuation of environmental benefits. The table on the following pages is the PAEP for the Last Chance Creek Phase II Project.

Project Assessment and Evaluation Plan

Last Chance Creek Watershed Restoration Project Phase II

GOALS	DESIRED OUTCOMES	OUTPUT INDICATORS	OUTCOME INDICATORS	TOOLS	TARGETS
Improve groundwater storage in floodplain	- Maximized floodplain water storage	- Completed on-the-ground project	- 75% elevational rise in April groundwater levels at Coyote Flat - Conversion of xeric to moist/mesic plant communities	- Monthly sampling of existing groundwater monitoring wells at Coyote Flat - Three 100' vegetative transects per treated meadow	- Saturated shallow aquifer in floodplains in April - No sagebrush in floodplain meadows
Improve annual hydrograph	- Attenuate peak flows -Augment summer base flow	- Completed on-the-ground project	- Similar storm pre- and post-project peaks flattened by 10% - Daily average summer flow increased by 25%	- Doyle Crossing continuously recorded flow data compared between similar pre- and post-project years.	- Maximized peak length (cannot predict) - Summer daily average flow not less than 10% of annual daily average flow
Improve water quality	- Decreased water temperatures - Decreased fine sediments	- Completed on-the-ground project	- 5% decrease in max daily water temperature at Doyle Xing - 10% decrease in <2mm size class substrate materials at pool tails at FRCRM Monitoring on Last Chance Cr - 10% decrease in turbidity and TSS in event grab samples at Doyle Xing and 3 other accessible points in the project area	- Continuous recording water temperature sensor at Doyle Xing - Wolmann pebble counts & pooltail fines grid toss at FRCRM Monitoring Reach - Storm event grab samples and in-house analysis pre- and post-project	- Not to exceed 20C max daily water temperature - <10% fines at pooltails and riffles - Event turbidity and TSS consistently trending downward
Improve coldwater fish habitat in Last Chance watershed	All of the above, plus: - increased shade - increased bank vegetative cover - increased pool:riffle ratio - increased % EPT of total macroinvertebrate biomass	- Completed on-the-ground project	At the FRCRM Monitoring Reach on Last Chance Cr: - 10% increase in shade - 10% increase in bank veg cover - increase pool habitat by 20% - increase EPT biomass by 10%	At the FRCRM Monitoring Reach on Last Chance Cr: - solar pathfinder - SCI bank stability rating (veg cover) - SCI habitat identification (% pools) - California Rapid Bioassessment	- 40% shade - 80% bank veg cover - 50% pool habitat - 80% EPT biomass

GOALS	DESIRED OUTCOMES	OUTPUT INDICATORS	OUTCOME INDICATORS	TOOLS	TARGETS
Improve coldwater fishery	- Increased trout population	- Completed on-the-ground project	- 10% increase in trout biomass at FRCRM Monitoring Reach on Last Chance Cr & at three sample sites within the project area	- Multiple pass depletion electroshock surveys	- Trout biomass not less than 30 lb/acre of surface water
Improve channel stability	- Decreased entrenchment - Decreased width:depth ratio	- Completed on-the-ground project	- 50% decrease in entrenchment (floodplain width/2xbankfull width) - 30% decrease in width:depth ratio	At 8 sample cross-sections within the project area: - SCI entrenchment & width:depth ratio surveys and calcs	- Entrenchment ratio not less than 10 - Width:depth ratio not greater than 1
Increased riparian vegetative condition	-Riparian community that includes structure and function	- Completed on-the-ground project	- 50% increase in willow/sedge/perennial grass species adjacent to channels	- Modified "greenline" survey from Monitoring Manual (Herrick et al. 2005) in each treatment reach of the project area	- No sagebrush or annual grasses adjacent to channels

REFERENCES

Herrick, J.E., J.W. VanZee, K.M. Havstad, L.M. Burkett & W.G. Whitford. 2005. Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems. USDA-ARS *Jornada* Experimental Range. Las Cruces, New Mexico. ISBN 0-9755552-0-0

In the following tables, the place and project names have been shortened as follows.

- LCC I abv DOY - Last Chance Creek Phase I Project
- LCC II - Last Chance Creek Phase II Project
- GV - Genesee Valley Project
- Genesee w/abv - Genesee Valley Project with the upstream regions (including LCC II, Upper Indian Creek, Red Clover Creek Project and Ward Creek and Hosslekuss Creek projects)
- PNF- Plumas National Forest Project NFFR- North Fork of the Feather River Watershed
- EBNFFR - East Branch North Fork of Feather River Watershed

Projected monthly baseflow increase at the outlet of East Branch North Fork Feather River in the 11year period, 1983-1994.

Unit: ac-ft	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
LCC II	23.1	-14.4	-43.1	-44.5	-141.4	-142.8	14.7	126.3	49.2	35.5	31.8	29.6
PNF	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
GV	41.1	40.8	40.1	39.9	39.6	39.4	39.0	39.5	40.1	41.5	41.5	41.4
Total impact	**80.9**	**43.0**	**13.6**	**12.0**	**-85.2**	**-86.8**	**70.3**	**182.5**	**105.9**	**93.7**	**90.0**	**87.6**
Flow of EBNFFR	10801	28626	48191	62389	69966	125550	67965	70470	33392	10754	8788	8140
Percent change	0.75%	0.15%	0.03%	0.02%	-0.12%	-0.07%	0.10%	0.26%	0.32%	0.87%	1.02%	1.08%

Projected monthly baseflow increase at the outlet of East Branch North Fork Feather River in the dry year, 1987.

Unit: ac-ft	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
LCC II	35.7	6.8	-27.6	-141.7	-6.4	-16.2	5.8	6.3	-1.3	13.6	53.5	59.1
PNF	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
GV	41.1	40.8	40.1	39.9	39.6	39.4	39.0	39.5	40.1	41.5	41.5	41.4
Total Impact	93.4	64.2	29.1	-85.2	49.8	39.8	61.5	62.5	55.4	71.7	111.6	117.0
Flow of EBNFFR	6571	9680	75295	166942	30101	26242	21814	18292	11644	9182	8607	8539
Percent Change	1.42%	0.66%	0.04%	-0.05%	0.17%	0.15%	0.28%	0.34%	0.48%	0.78%	1.30%	1.37%

Projected baseflow increase at the outlet of East Branch North Fork Feather River during dry months (June-Oct) in the 11-year period, 1983-1994.

Flow at the outlet of EBNFFR (ac-ft)	71875
Baseflow increase (ac-ft)	458
Percentage increase (ac-ft)	0.64%

Projected baseflow increase at the outlet of East Branch North Fork Feather River during dry months (June-Oct) in the dry year, 1987.

Flow at the outlet of EBNFFR (ac-ft)	44543
Baseflow increase (ac-ft)	449
Percentage increase (ac-ft)	1.01%

A Continuum of Benefits

The continuum of a 20-year watershed restoration effort in the Upper Feather River region generates measurable and cumulative watershed benefits both locally and downstream.

Water supply and quality benefits from past projects, where monitoring data is available, are displayed in the following tables. These tables demonstrate that water supply and quality benefits are cumulative and that the predicted benefits from the proposed projects are quite certain, since actual benefits from these past projects have been documented through monitoring. See the Feather River CRM website: www.Feather-River-CRM.org (under "publications") for monitoring data that are included in modeling simulations of completed projects in the tables below.

Projects Completed 1985-2005

Subwatershed	Stream Name/Phase	Miles/Acres	Restoration Technique	Timeline
Last Chance	**Cottonwood/Big Flat**	**1.0/47**	**Meadow re-watering**	**Complete 1995**
" "	**Clarks/Phase I**	**1.0/56**	" "	**Complete 2001**
" "	**Stone Dairy**	**.6/22**	" "	**Complete 2001**
" "	**Mainstem Phase I**	**7.0/800**	" "	**Complete 2004**
Red Clover	**Red Clover Demo Pjt**	**1.0/70**	**Check dams**	**Complete 1985**
" "	Red Clover Phase I	3.5/345	Meadow re-watering	2005 thru 2006
" "	**Bagley Creek**	**.3/15**	" "	**Complete 1997**
Indian Creek	**Boulder Creek**	**.6/30**	" "	**Complete 1997**
" "	**Ward Creek**	**1/165**	" "	**Complete 1999**
" "	**Hosselkus- Phase I /II**	**.75/65**	" "	**2001/2005**
" "	**Wolf Creek Phase I-III**	**2.5/70**	**Geomorphic channel/reveg**	**1990 thru 1999**
Spanish Creek	**Greenhorn- Farnworth**	**.75/20**	**Geomorphic channel/reveg**	**Complete 1991**
	TOTALS	**20/1705**		

Projected baseflow increase including completed project effects at the outlet of East Branch North Fork Feather River during dry months (June-Oct) in the 11-year period, 1983-1994.

Flow at the outlet of EBNFFR (ac-ft)	71875
Baseflow increase (ac-ft)	759
Percentage increase (ac-ft)	1.06%

Projected baseflow increase including completed project effects at the outlet of East Branch North Fork Feather River during dry months (June-Oct) in the dry year, 1987.

Flow at the outlet of EBNFFR (ac-ft)	44543
Baseflow increase (ac-ft)	734
Percentage increase (ac-ft)	1.65%

Projected monthly baseflow increase including completed project effects at the outlet of East Branch North Fork Feather River in the 11year period, 1983-1994.

Unit:ac-ft	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
LCC II	23.1	-14.4	-43.1	-44.5	-141.4	-142.8	14.7	126.3	49.2	35.5	31.8	29.6
PNF	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
GV	41.1	40.8	40.1	39.9	39.6	39.4	39.0	39.5	40.1	41.5	41.5	41.4
Existing project	41.0	-25.6	-76.6	-78.9	-251.0	-253.4	26.1	224.3	87.4	63.1	56.5	52.6
Total impact	121.9	17.4	-63.0	-66.9	-336.3	-340.2	96.4	406.7	193.3	156.8	146.5	140.1
Flow of EBNFFR	10801	28626	48191	62389	69966	125550	67965	70470	33392	10754	8788	8140
Percent Change	1.13%	0.06%	-0.13%	-0.11%	-0.48%	-0.27%	0.14%	0.58%	0.58%	1.46%	1.67%	1.72%

Projected monthly baseflow increase including completed project effects at the outlet of East Branch North Fork Feather River in the dry year, 1987.

Unit:ac-ft	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
LCC II	35.7	6.8	-27.6	-141.7	-6.4	-16.2	5.8	6.3	-1.3	13.6	53.5	59.1
PNF	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
GV	41.1	40.8	40.1	39.9	39.6	39.4	39.0	39.5	40.1	41.5	41.5	41.4
Existing project	63.4	12.1	-49.0	-251.6	-11.3	-28.7	10.4	11.3	-2.4	24.1	94.9	104.9
Total impact	156.8	76.3	-19.8	-336.8	38.5	11.1	71.9	73.7	53.0	95.8	206.5	221.9
Flow of EBNFFR	6571	9680	75295	166942	30101	26242	21814	18292	11644	9182	8607	8539
Percent Change	2.39%	0.79%	-0.03%	-0.20%	0.13%	0.04%	0.33%	0.40%	0.46%	1.04%	2.40%	2.60%

Water Supply for Environmental Purposes

Projects provide environmental benefits to instream environments both within the project area and also downstream of the project areas. Beginning within four years after project implementation, water benefits are perpetual. Once restored stream and floodplain systems are properly functioning they are largely self-maintaining so that benefits extend indefinitely. For practical purposes, 50 years of benefits have been used for ecosystem projects and 20 to 30 years have been used for the two water treatment infrastructure projects. Environmental benefits are secured through perpetual easements on private lands and through public ownership. The two Feather River Land Trust projects and a National Forest project dedicate perpetual instream flows specifically for coldwater environmental habitat purposes such as reducing temperature stress on salmonids during peak heating periods or increasing baseflows during critical low flow periods.

All projects integrate the management of winter floodwaters and summer irrigation waters to maximize infiltration and of naturally filtered surface waters into dewatered aquifers, and thereby, producing measurable instream flow benefits during the summer baseflow period. Increased summer baseflows and reduced summer water temperatures directly benefit both the coldwater fishery and water based recreation, both beneficial uses designated in the Central Valley Basin Plan,

Avoided Water Supply Projects or Shortages

The following tables display how watershed restoration projects in the East Branch improve operational flexibility for downstream water users during the summer baseflow period when water conflicts between instream uses and diversions for power and export water uses are highest. Riparian agricultural water diverters within the basin, municipal and agricultural diverters from the Lake Oroville facility at the terminus of the basin, and consumers of hydropower generation from power plants and reservoirs in the North Fork are all benefited by the implementation of projects that increase baseflows.

Operational flexibility during floods and droughts and during periods of lowest summer surface water quality benefits the 22 million users of the State Water Project and power consumers in PG&E's service area in Northern California. The projects, although involving less than 0.2% of the watershed area, measurably improve water supply and water quality and reduce flood peaks in the project area and downstream in the North Fork canyon where the State Water Project and PG&E water supplies and hydropower generation structures are located.

Impaired Water Body Names and Water Volumes

The North Fork Feather River has been proposed for 303(d) listing for temperature and mercury for 39 miles between Lake Almanor and Lake Oroville. Unimpaired (pre-hydroelectric project) summer flows on the North Fork were between 700 and 800 cfs. Currently, regulated summer flows range between 50 cfs and 150 cfs and are undergoing upward revision as part of the 401 Certification process undertaken by the SWRCB for project relicensing. Projects 1962, 2105, 2107, and 2100 are all located in the North Fork segment that is proposed for 303(d) listing.

Portion of Each Water Body Affected by the Proposed Projects

Temperature benefits (reduced stream temperatures of 2.5°F to 3.5°F) accrue to the North Fork canyon from the restoration projects that drain to the North Fork in the baseflow summer months (June-October). Sediment benefits (and associated mercury load reductions) accrue during the winter peak flow period. As shown by the following tables, projects proposed for the East Branch of the North Fork of the Feather River (EBNFFR) have the potential to positively and measurably affect summer stream temperatures in June in the downstream North Fork segment that is proposed for temperature listing. It is debatable whether upstream temperature benefits accrue to the whole 39 miles because during July, August, September, and October regulated hydro-project operation flows are delivered from storage at Lake Almanor and from Buck's Lake. These flows overwhelm the contribution of natural baseflows by the East Branch to the North Fork segment that is proposed for 303(d) listing.

Pollutants Present in the Affected Water Body and Sources of Pollutants

The sources of mercury pollution originate from eroding, inert free mercury deposits from upstream abandoned gold and copper mines. Inert mercury is transported in suspended sediments during the winter flood flow season. If suspended sediments are not recaptured onto floodplains in the upper watershed, they become trapped behind hydroelectric power supply dams in the North Fork or they are captured by the State Water Project's Lake Oroville water supply at the terminus of the Upper Feather basin.

Expected Load Reductions and Change in Pollutant Concentrations

Approximately 1.1 million tons of sediment annually erode from streambanks and roads in the North Fork watershed during an average runoff year. Of that total, 880,000 tons or 80 percent originates from human-caused activities, including abandoned mine tailing piles. The EBNFFR Prop. 50 projects (Last Chance Creek Phase II, the Genesee Valley Integrated Water Management Project, and Quincy Wetlands Treatment Project) create 1,586 acres of restored floodplains and riparian corridors which trap suspended sediments from overland flows. The proposed projects will reduce sediment loads into the North Fork canyon by 61,433 tons per year (5%).

Sediment Benefits

	Spre(t/yr)	Spost(t/yr)	DS=(Spost-Spre)	%
LCC II	147006	129290	-17716	-12.05
Genesee (w abv)	542711	487032	-55679	-10.26
EBNFF	1100000	1038557	-61443	-5.59

Temperature Benefits

The Indian Creek Watershed Study, prepared by the Soil Conservation Services in 1993, predicts a 2.3°F reduction in summer stream temperatures from a 25 percent increase in riparian shading and a 3.9°F decrease in summer stream temperatures from a combination of 25 percent increase in riparian cover and a 50 percent decrease in stream width in Indian and Genesee valleys. Genesee and Indian Valleys are the largest and lowest elevation valleys in the EBNFFR (pp. 37-38).

Monitoring of the recently completed Last Chance Creek Phase I meadow rewatering and stream rehabilitation project has documented a 10°F reduction in stream temperatures from the top of the project area to the downstream end of the project (4 miles) in June 2004, the first year after reconstruction.

In 2006, the following study was completed in the basin: Quantifying Stream-Aquifer Interactions through the Analysis of Remotey Sensed Thermographic Profiles and In Situ Temperature Histories. Steven P. Loheide and Steven Gorelick, the authors, conclude that, "*Observed spatial and temporal patterns of stream temperature are consistent with an increase in baseflow and hyporheic exchange between the middle restored reach when compared to groundwater fluxes in the surrounding unrestored reaches. One implication is that pond and plug stream restoration may improve aquatic habitat by depressing maximum stream temperatures by >3°C.*" This study was located in the Cottonwood Creek area of the Last Chance Creek watershed. The "pond and plug" restoration technique refers to the meadow rewatering stream channel stabilization approach that will be applied in the proposed Last Chance Creek Phase II Project.

Other experts have documented 2°F to 4°F cooler water in stream pool bottoms of shaded, low width-depth ratio streams having good pool-riffle ratios. (R. Flint, retired California

Fish and Game; E. Theiss, NOAA Fisheries; L. Kavvas, UCD, California Hydrologic Research Laboratory: personal communications with Leah Wills, Plumas County Flood Control District).

A feasible outcome from successful stream rehabilitation could be as much as 11°F cooling of waters at the bottoms of three or more foot deep pools in streams overhung by at least 25 percent riparian vegetation. Reductions in baseflow temperature are accomplished from a combination of restoration techniques including stream channel rehabilitation and riparian area re-vegetation, and through improving groundwater infiltration in meadows and floodplains that are reconnected to adjacent streams.

As examples, the meadow and stream restoration projects in the East Branch of the North Fork of the Feather River (EBNFFR) are predicted to improve summer baseflow temperatures by 2.5°F in June in the North Fork canyon, at least to the confluence of the East Branch with the Upper North Fork at Belden.

Stream Water Temperature Benefits of the project

June

	Tpre (°F)	Tpost (°F)	DT (°F)	%
LCC II	64.96	53.14	-11.82	-18.20
Genesee	65.22	60.18	-5.04	-7.72
Taylorsville	68.83	64.76	-4.07	-5.91
EBNFF	66.38	63.84	-2.54	-3.82

July

	Tpre (°F)	Tpost (°F)	DT (°F)	%
LCC II	69.64	57.99	-11.66	-16.74
Genesee	68.73	60.15	-8.58	-12.48
Taylorsville	73.82	67.74	-6.08	-8.24
EBNFF	68.17	64.58	-3.59	-5.27

August

	Tpre (°F)	Tpost (°F)	DT (°F)	%
LCC II	66.09	54.62	-11.47	-17.35
Genesee	67.72	59.90	-7.83	-11.56
Taylorsville	73.86	68.21	-5.65	-7.65
EBNFF	67.71	64.38	-3.32	-4.91

Tpre - the water temperature under the pre-project condition;
Tpost - the water temperature under the post-project condition;

Estimation of the Stream Water Temperature Benefits for the East Branch North Fork of the Feather River Watershed and Water Quality Improvement Projects

In order to estimate the stream water temperature effects from upstream to Indian Creek at Taylorsville in the Upper Feather River watershed, we established four linear regression equations at particular locations described below and then applied the regression curves to compute the multiple-year averaged monthly summer temperature for the pre- and post-project conditions. The emphasis is on estimating temperature benefits of two regions: East Branch North Fork of the Feather River and Sierra Valley.

From the Feather-River-CRM website, we retrieved concurrent daily temperature and flow data at six stations, LCC@Doyle Crossing, Red Clover Cr. @ Notson, Indian Cr. @ DWR weir, Indian Creek @ Flournoy, Lights Creek, and Wolf Creek, from Oct.1999 to Sep. 2004, and also temperature data at other six stations, LCC @ Murdock, Red Clover Creek at Drum Bridge, Indian Creek at Taylorsville, Indian Creek above Spanish Creek, Spanish Creek near Camp Wallace and East Branch North Fork of the Feather River, from June to August in 2001, in the East Branch North Fork of the Feather River. It should be mentioned that the station, Indian Cr. @ Taylorsville, actually has temperature data in summer months from 1999 to 2004, but it does not have flow data in the summer months. We also retrieved the flow data at Indian Creek above Spanish Creek and Spanish Creek near Camp Wallace from Oct. 1999 to Sep. 2004 from the USGS website. All the temperature and flow data in the summer months, from June through August, were chosen and averaged into monthly values in each year.

Based on the heat balance of each confluence in the stream network, we established six linear equations in which the heat fluxes (QT – the product of flow rate and temperature) from the upstream stations which have a common downstream station, were linearly related to the heat flux at that downstream station. Since some of the stations do not have flow data, we estimated their discharges by considering the correlations between the unknown stations and those known.

Since all the stations have data in 2001, we used the monthly-averaged data of this year to calculate the parameters in those linear regression equations. For each month from June through August, the linear regression equations are given as follows:

$$QT_{Murdock} = a1 * QT_{Doyle} + b1 \quad (1)$$
$$QT_{Drum} = a2 * QT_{Noston} + b2 \quad (2)$$
$$QT_{Flournoy} = a3 * QT_{DWR} + b3 * QT_{Murdock} + c3 * QT_{Drum} + d3 \quad (3)$$
$$QT_{Taylorsville} = a4 * QT_{Flournoy} + b4 \quad (4)$$
$$QT_{abv\text{-}Spanish} = a5 * QT_{Taylersville} + b5 * QT_{Lights} + c5 * QT_{Wolf} + d5 \quad (5)$$
$$QT_{EBNFF} = a6 * QT_{abv\text{-}Spanish} + b6 * QT_{Spanish\text{-}Camp} + c6 \quad (6)$$

The parameters are determined through calibration as follows,

a1	1.64	b1	0.15				
a2	0.81	b2	2.00				
a3	1.59	b3	1.50	c3	1.00	d3	29.90
a4	1.90	b4	240.0				
a5	1.65	b5	1.5	c5	1.3	d5	50
a6	1.17	b6	1.07	c6	36		

Once the parameters were determined based on the data in 2001, multiple-year averaged monthly temperatures and flows of those stations that have data for several years were plugged into the equations to estimate the averaged monthly temperature from upstream to Taylorsville in the watershed. Two scenarios were computed: pre- and post-project. Under pre-project conditions the known averaged monthly T and Q were used directly in the developed linear regression equations, while in the post-project conditions the T and Q were adjusted due to the project benefits. Three projects, Last Chance Creek Watershed restoration project Phase II, Genesee valley integrated resource management project, and Plumas National Forest project, are proposed in this region. The Upper Feather River Watershed and Water Quality Improvement project proposal provides some records and project research about the stream cooling by the water management and watershed management. We took the values from the given PAEPs of the above-mentioned proposed projects as our basic assumptions for the temperature reduction by restoration, the increase of groundwater recharge due to vegetation cover, riparian shading and the decrease in stream width respectively.

As for the restoration effect, the Last Chance Creek (LCC) meadow rewatering and stream rehabilitation caused a 10°F reduction in stream water temperature from the top of the project area to the downstream end of the project in June 2004, the first year after the restoration in LCC[1]. Considering the distance from the project location to the outlet of the watershed and higher stream water temperatures from other tributaries to the outlet of watershed, the stream water reduction from the already completed LCC restoration project will be diminished by the time the stream water from that project's area ends up at the watershed outlet. Also based on 30 years of watershed monitoring experience, the group of projects for the national forest water quality improvement, including the meadow restoration, lower instream summer water temperature by at least 6 degrees Fahrenheit. Therefore, 6° F degree decrease due to restoration at the Upper Last Chance Creek watershed at Doyle Crossing was used in our estimation.

Groundwater recharge increase because of vegetation cover was computed by using the baseflow increase based on our previous estimation and the percentage of cover increase from the PAEP of LCC, Genesee, and national forest projects. The groundwater temperature was assumed as 50°F, since the groundwater temperatures in the gravels in the rewatered reach were in the range of 50°F to a high of 58°F.

Flood Attenuation

The 800 acre meadow re-watering project in Last Chance Creek results in a measurable reduction in flood peaks entering Lake Oroville. The site-specific discharge information needed to quantify flood reduction benefits for the other projects was not available. Therefore the flood benefits are estimated as percentages. When considering flood benefits, it important to remember that the Step 2 projects affect less than 0.2% of the total Upper Feather River watershed area (4,768 acres of 2,307,042 acres).

Flood attenuation is one of the multiple benefits of meadow rewatering and floodplain restoration projects. The flood benefit was measurable only for the Last Chance Creek Watershed Restoration, Phase II Project (LCC II). Three hundred and eighty six acre feet of annual flood storage on 800 acres of restored floodplain and stream channel in the Last Chance

Creek system, is the predicted flood reduction benefit for the LCCII Project. Estimation methods, discussed below, predict a 3.7 % reduction in flood peaks s for the North Fork projects measured at the upstream end of the North Fork Canyon. The 800 Last Chance Creek II Project has a barely measurable (less than a 0.1% flood benefit to Lake Oroville . Flood peak reduction is estimated at 3.7% at the outlet of the East Branch in the North Fork drainage. Local benefits include a reduction in the erosive flood forces on degraded streambanks downstream of the projects, and less flooding risk for flood-prone houses in the Indian and American Valleys.

Estimation of the Flood Peak Benefits by the Upper Feather River Prop. 50 Project Package

The estimation of the flood peak reduction by the Prop. 50 projects is obtained by calculating the daily average flood peak discharges in different subwatersheds under the pre- and post-project scenarios. The basic formula used to compute the discharge is the rational method formula,

$$Q = C*I*A$$

where Q is the discharge, C is the runoff coefficient which represents the integrated effects of watershed conditions on the peak discharge of runoff, I is the precipitation intensity, and A is the subwatershed area. The precipitation intensities are obtained from our reconstructed climate data, and the subwatershed areas are obtained after they are delineated by a GIS.

Since the pre- and post-project I's and A's of each subwatershed are equal, the actual difference between the pre-project flood peak and the post-project flood peak discharges comes from the difference in the coefficients C's of the two scenarios. Then the computation of C's is the main problem for this estimation. The values of C for the two scenarios need to be determined before the peak discharges are estimated.

The pre- and post-project discharges of the Last Chance Creek (LCC) at Doyle Crossing for 11 continuous years during 1982-1993 were computed by the WEHY watershed hydrology model. Mar. 13, 1983 was chosen as the representative date for flood peak discharge, since this day has the highest flood discharge value in the year 1983.

As for the pre-project scenario, the coefficients C_p (replacing "C" in equation (1)) of all the subwatersheds are assumed to be equal. Since the Q, I, and A of LCC at Doyle Crossing are known, the C_p of this subwatershed can be computed directly. We applied the C_p of LCC to other unknown subwatersheds, such as Genesee valley, the basin upstream of Genesee, and Sierra Valley. There are two flow stations on the Indian Creek and the Spanish Creek close to the outlet of East Branch North Fork of Feather River (EBNFF). The observed discharges at these two stations are summed to obtain the discharge for the EBNFF and then the discharge is applied to calculate its own C_p.

As for the post-project scenario, the coefficient C_{pt} (replacing "C" in equation (1)) is computed based on different management activities, such as restoration, vegetation cover, and weir construction.

Since the pre- and post-project discharges at LCC are known, the restoration effect is expanded to other subwatersheds with restoration by following the formula,

$$\left[\frac{(C_{pt}-C_p)/C_p}{A_{restore}/A_{wsd}}\right]_{wsd^*}=\left[\frac{(C_{pt}-C_p)/C_p}{A_{restore}/A_{wsd}}\right]_{LCC} \tag{2}$$

where $A_{restore}$ is the restoration area in the subwatershed, A_{wsd} is the subwatershed area, wsd^* is the subwatershed which has restorations, and LCC is LCC at Doyle Crossing.

The vegetation cover effect is considered through the variation of Manning's roughness coefficient n. We know that the increase of vegetation cover along the stream banks or floodplains will increase the roughness. From a comparison of the Manning's equation $Q = AR^{2/3}S^{1/2}/n$ and the equation (1), we know that C is proportional to 1/n, and then derive the following relationship in order to compute C_{pt};

$$\frac{C_{pt}-C_p}{C_p}=\frac{1/n_{pt}-1/n_p}{1/n_p} \tag{3}$$

We obtained the values of roughness from the Open-Channel Flow book by Chaudhry[1].

The weir constructions in Sierra Valley will hold the water at the upstreams of the weirs, and reduce the discharge by spreading the water over the floodplain since that region is very flat. The discharge over a weir can be computed by

$$Q = C_d L H^{3/2} \tag{4}$$

where C_d is a coefficient, L is the length of the weir and H is the water depth over the weir. This coefficient can be found from Rehbock's experimental formula,

$$C_d = 0.611 + 0.08*h/w \qquad \text{for } h/w \le 5 \tag{5}$$

Since the water will spread widely over the flat wetland at Sierra Valley, the water flow depth over this wetland will be very small, and the ratio of flow depth to width, h/w, should be less than 5. Once the post-project discharge is computed, one can obtain the C_{pt} from equation (1).

The daily-average flow peak discharge benefits of the project are listed in the following table:

Daily-Average Flow Peak Discharge Benefits of the Projects

	A	IA	Qpre-k	Cp	Qpre	Qpost-k	Cpt	Qpost	%
	(m^2)	(m^3/s)	(m^3/s)		(m^3/s)	(m^3/s)		(m^3/s)	
LCC I abv DOY	249201360	77.18	32.36	0.419		27.80	0.360		-14.08
LCC II	522672331	170.41			71.44		0.386	65.86	-7.82
Genesee	118095424	36.75			15.41		0.408	15.00	-2.65
Genesee (w abv)	1248008418	449.78			188.56		0.406	182.57	-3.18
EBNFF	2460738331	1958.94	759.77	0.388			0.376	731.63	-3.70
Sierra Valley	1359848788	520.65			218.27		0.380	197.84	-9.36

A – the area of each watershed;
IA – the product of precipictation density and watershed area;
Qpre-k – the daily-average discharge under the pre-project condition known by observations or previous numerical simulations;
Cp – the discharge coefficient under the pre-project condition;
Qpre – the daily-average discharge under the pre-project condition Qpre = Cp*I*A;
Qpost-k - the daily-average discharge under the post-project condition known by obervations or previous numerical simulations;
Cpt - the discharge coefficient under the post-project condition;
Qpost - the daily-average discharge under the post-project condition Qpost = Cpt*I*A;
% - the peak discharge reduction - 100*(Qpost-Qpre)/Qpre.

Watershed name:

LCC I abv DOY - Last Chance Creek above Doyle Crossing
LCC II - Last Chance Creek Phase II region
Genesee - Genesee valley only
Genesee (w abv) - Genesee valley with the upstream regions, including LCC II, Upper Indian Creek, Red Clover Creek and Genesee
EBNFF - East Branch North Fork of Feather River Watershed
Sierra Valley
Lake Davis - Lake Davis- Long Valley watersheds
UMFF - Upper Middle Fork of Feather River Watershed

Note: Last Chance I is an already implemented project. This project demonstrates that the benefits are being generated the first winter after construction.

Power Cost savings and Production

These estimates are displayed in the three following tables. Only projects in the North Fork of the Feather River are used.

Unit: ac-ft	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
LCC II	35.7	6.8	-27.6	-141.7	-6.4	-16.2	5.8	6.3	-1.3	13.6	53.5	59.1
PNF	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
GV	41.1	40.8	40.1	39.9	39.6	39.4	39.0	39.5	40.1	41.5	41.5	41.4
Total Impact	93.4	64.2	29.1	-85.2	49.8	39.8	61.5	62.5	55.4	71.7	111.6	117.0
Flow of EBNFFR	6571	9680	75295	166942	30101	26242	21814	18292	11644	9182	8607	8539
Percent Change	1.42%	0.66%	0.04%	-0.05%	0.17%	0.15%	0.28%	0.34%	0.48%	0.78%	1.30%	1.37%

Projected baseflow increase at the outlet of East Branch North Fork Feather River during dry months (June-Oct) in the 11-year period, 1983-1994.

Flow at the outlet of EBNFFR (ac-ft)	71875
Baseflow increase (ac-ft)	458
Percentage increase (ac-ft)	0.64%

Projected baseflow increase at the outlet of East Branch North Fork Feather River during dry months (June-Oct) in the dry year, 1987.

Flow at the outlet of EBNFFR (ac-ft)	44543
Baseflow increase (ac-ft)	449
Percentage increase (ac-ft)	1.01%

Value of Additional Power Generated

The value of the additional electricity generation is based on the additional acre feet of water transferred from winter release to early summer release to the Middle and North Forks of the Feather River, the price per megawatt hour, and the amount of generating capacity on each of the river forks. Total water released is 2,323 acre feet, 375 of which will enter the North Fork and the remainder, or 1,948 will be released to the Middle Fork. Water flowing down the North Fork will generate power at the Rock Creek, Cresta, Poe, and Oroville/Thermalito power houses, while water in the Middle fork will affect power generation at Oroville/Thermalito only.

The amount of power generated by a given flow of water is derived from a model incorporated into *A Cost-Benefit Analysis of Flow Alternatives Associated with Pacific Gas and Electric's Rock Creek-Cresta Project Relicensing,* Resource Decisions, 1999. The report estimates annual generation for the Rock Creek-Cresta power plants only but these figures are used to project generation for the other affected plants in the system using the ratio of the individual plant head to that of Rock Creek-Cresta. Based on this approach each acre foot of water released into the North Fork of the Feather River will generate just over 1.66 mWh's, while an acre foot released into the Middle Fork will produce just 1.03 mWh's. Thus additional generation will total 2,630.5 mWh's, 624 on the north Fork and 2,006.5 on the Middle Fork.

The value of a mWh is the market price plus the externality cost of generation using fossil fuels. The average price per mWh for the period 2007-10 is $73.36 (Platts Megawatt Daily, March 9, 2006) and the average for the third quarter (more representative of peak power values) of 2006-2008 is $78.83. The externality cost per mWh is $5.60 in 1990$ or $6.76 in 2006$. Using the more conservative annual average price ($73.36/mWh) and adding the 2006$ externality cost results in a value of $80.13/mWh.

Multiplying the additional mWh's generated by the value of a mWh results in a 2006 value for the additional power generation of $210,765. Discounting at six percent interest for seven years results in a first year of project (2013) value of $140,171 and a 50-year present value (using a 6% discount rate) of $2,349,528.

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Quantifying Stream–Aquifer Interactions through the Analysis of Remotely Sensed Thermographic Profiles and In Situ Temperature Histories

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The interaction between surface and subsurface waters through hyporheic exchange and baseflow is critical to maintaining ecological health in streams. During warm periods, groundwater–surface water interactions have two primary effects on stream temperature: (1) cool groundwater discharging as baseflow lowers stream temperature and (2) hyporheic exchange buffers diurnal stream temperature variations. We demonstrate, for the first time, how high-resolution, remotely sensed forward-looking infrared (FLIR) images and instream temperature data can be used to quantify detailed spatial patterns of groundwater discharge to a 1.7 km reach of Cottonwood Creek in Plumas National Forest, CA. We quantify the individual effects of baseflow and hyporheic exchange on stream temperatures by simulating the stream energy budget under different conceptual models of the stream–aquifer interaction. Observed spatial and temporal patterns of stream temperature are consistent with an increase in baseflow and hyporheic exchange within the middle, restored stream reach when compared to groundwater fluxes in the surrounding, unrestored reaches. One implication is that pond and plug stream restoration may improve the aquatic habitat by depressing maximum stream temperatures by >3 °C (K).

Introduction

Hydrologists, stream ecologists, aquatic chemists, and water resource managers are often unable to quantify water and thermal fluxes across the streambed interface, even though these exchanges administer significant control on relevant physical and chemical processes (*1*, *2*, *3*). For instance, groundwater discharge to streams accumulates throughout a watershed's drainage network as baseflow, which supports river flow during dry periods, maintains aquatic ecosystems, and is critical to humans for water supply and agriculture. Hyporheic water flow from the stream into the subsurface and back to the stream plays important roles in thermal buffering, nutrient cycling, and stream ecology (*1*, *4*, *5*). Direct measurement of groundwater discharge to a stream at a point is challenging, and obtaining representative point measurements throughout a watershed is a practical impossibility. Understanding, protecting, and restoring the hydrologic function and ecosystem services provided by baseflow and hyporheic exchanges requires better methods for quantifying these spatially distributed fluxes.

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Commercial availability of forward-looking infrared (FLIR) cameras has made it feasible to monitor stream temperature (T_s) from helicopter-based platforms (*6*). High-resolution thermal data can be used for the identification and protection of thermal refugia for fisheries (*7*) and may provide clues about surface water–groundwater interactions (*8*, *9*). For example, stream reaches with high groundwater contributions have lower daily maximum temperatures during the summer months because groundwater remains cool relative to the stream. We present a new method to quantify both groundwater discharge (baseflow) and hyporheic exchange that relies on the detailed thermal signature in the stream over space and time.

The method involves collecting airborne thermographic imagery to obtain longitudinal profiles of T_s at various times during the day and recording instream temperature at selected locations. These thermal profiles and histories are then simulated with a modified version of an existing, one-dimensional (1-D) energy budget/transport model (*10*). Input parameters such as meteorological conditions, vegetative shading characteristics, and stream characteristics were measured on-site, estimated from aerial photographs, and extracted from existing databases. The rates of groundwater inflow and hyporheic exchange were systematically varied until the modeled T_s matched both the in situ and the remotely sensed observations.

The methodology developed here was applied to a 1.67 km reach of Cottonwood Creek in Plumas National Forest, CA (Figure 1). This reach runs through Big Flat, a meadow that was restored in 1995 to reestablish the hydrologic regime and natural vegetation. The meadow had been adversely affected by stream incision, which had caused subsequent meadow dewatering, a change in the hydrologic regime, and a succession from native wet meadow vegetation to sagebrush and dryland grasses (*11*, *12*). This is likely a result of increased erosion caused by land-use practices such as grazing and logging. The pond-and-plug restoration technique involved excavating ponds along the incised channel and filling in the old channel neighboring these ponds (*11*, *12*). The stream was rerouted from the old, deeply incised channel into a newly constructed, unincised, Rosgen type "E" (*13*) channel, to which pool and riffle treatment was performed in 2004. The restoration objective of raising the water table (1) promoted a reestablishment of wet meadow vegetation and (2) increased groundwater flow to the stream through baseflow augmentation (*14*). Groundwater flow into the stream is from regional aquifers and the seasonal drainage of meadow sediments. Hyporheic flow is the local scale exchange of water between the stream and the hyporheic zone on short time scales. The work presented is being used to evaluate the effectiveness of baseflow augmentation.

Methodology

On June 3, 2005, thermal imagery was collected over Cottonwood Creek in Big Flat using methods similar to those used by Torgersen et al. (*15*). A S65 FLIR camera was held in a near vertical position with a manually steered mount beneath a helicopter that flew over the reach, in a downstream direction, four times throughout the day. The camera has a spectral range of 7.5–13 μm and a 24 × 18° field of view. The flight times were 7:43 am, 11:53 am, 4:08 pm, and 7:38 pm. The helicopter altitude was ~120–160 m, resulting in image resolution of 0.16–0.21 m. Longitudinal profiles of T_s for each flight were created by sampling an approximately circular footprint of 0.3–1.2 m^2 consisting of an average of 9–30 neighboring pixels from the thermal images at intervals

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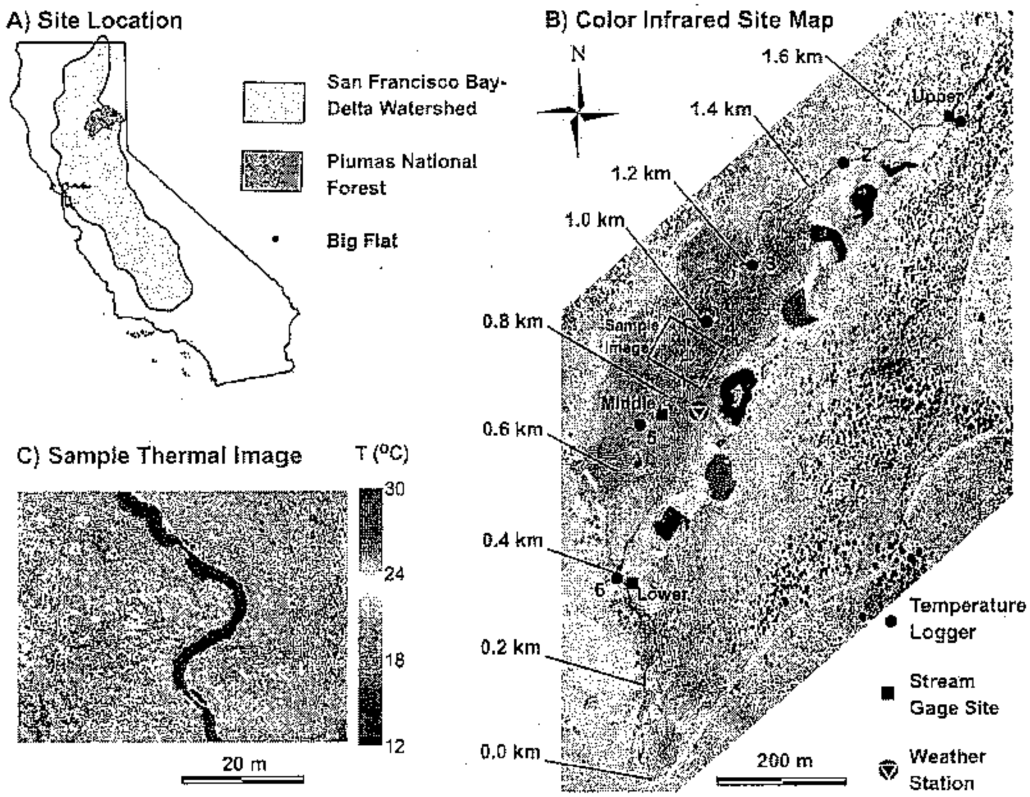

FIGURE 1. (A) Location of Big Flat in the Plumas National Forest, CA. (B) Color infrared base map of Big Flat shows healthy vegetation in pink/red and locations of stream temperature loggers, stream discharge measurements, and the weather station. Stream kilometer is measured upstream from the road crossing. The ponds on the eastern flank of the meadow were created during the restoration and mark the position of the former stream channel. (C) FLIR image showing temperature with a spatial resolution of ~18 cm. Other thermal images in the literature show springs that discharge cool water as a point source (i.e., Figure 1.7 in ref 10); however, in this study, we are interested in diffuse groundwater inflow, which is not visible in a single image but affects T_s at the reach scale.

of ~25 m. Since each flight lasted ~56 s through this reach, the resulting longitudinal profiles of T_s represent a nearly instantaneous snapshot.

Ground-based data served to crosscheck the thermography data, support the stream temperature model, and validate results. Stream bankfull width was measured at ~18 m intervals from stream kilometer 0.39 to 1.33 and was estimated elsewhere from aerial photographs. Streamflow measurements were taken at three locations using an acoustic Doppler velocimeter (SonTec). Instream temperature loggers (HOBO Water Temp Pro v1) recorded T_s at 15–30 min intervals at six locations (Figure 1).

Stream temperature was modeled using HeatSource V7.0, which is distributed at www.deq.state.or.us/wq/TMDLs/WQAnalTools.htm. Except where noted, the procedures outlined by Boyd and Casper (*10*) were used. This finite-difference model solves the 1-D, transient advection–dispersion equation. The model was modified to solve a more general, nonuniform form of this equation:

$$A\frac{\partial T_s}{\partial t} = -\frac{\partial (QT_s)}{\partial x} + \frac{\partial}{\partial x}\left(AD\frac{\partial T_s}{\partial x}\right) + \frac{W\Phi_{net}}{\rho C_p} \qquad (1)$$

In eq 1, T_s is the stream temperature [K]; t is time [s]; x is the distance downstream [m]; $A = A(x)$ is the cross sectional stream area [m^2]; Q is the streamflow [m^3/s]; D is the dispersion coefficient [m^2/s]; ρ is the density of water [kg/m^3]; C_p is the specific heat of water [J/K/kg]; $W = W(x)$ is the stream width [m]; and $\Phi_{net} = \Phi_{net}(x)$ is the net heat flux [J/s/m^2]. The Φ_{net} term accounts for the heat fluxes illustrated in Figure 2. The incoming shortwave solar loading (Φ_{solar})

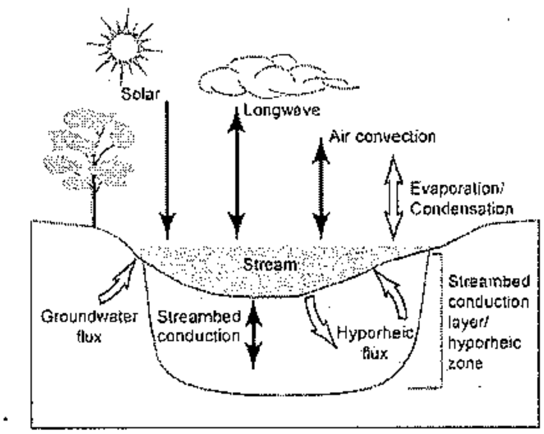

FIGURE 2. Heat exchange mechanisms affecting stream temperature.

reaching the stream surface is calculated based on geographic location, time of year, time of day, cloudiness, and topographic/vegetative shade. Cloudiness is calculated using the maximum predicted solar radiation and the actual solar radiation measured at the weather station (*16*); because we back-calculated cloudiness in this manner, the modeled shortwave radiation is, by definition, equivalent to the measured values. The longwave radiation ($\Phi_{longwave}$) is based on the difference between incoming longwave radiation from the atmosphere and back radiation emitted from the stream. Streambed conduction ($\Phi_{streambed}$) is driven by the temperature gradient between the stream and the streambed conduction layer (Figure 2). Similarly, the sensible heat flux

TABLE 1. Source of Data Required for Stream Temperature Modeling

data type	data source
vegetation shading	vegetation mapped from USGS digital ortho quads
topographic shading	10m USGS digital elevation models
stream slope	10m USGS digital elevation models[a]
bankfull width	measured on the ground and estimated from aerial photographs
stream velocity, width, and depth	modeled using Muskingum–Cunge flow routing in HeatSource
dispersion coefficient	estimated from streamflow, dimensions, and roughness (10)
sediment thermal properties	estimated based on porosity
groundwater temperature	measured at various locations within the meadow
cloudiness	recorded at weather station
air temperature	recorded at weather station
humidity	recorded at weather station
wind speed	recorded at weather station
discharge bound. condition	measured (acoustic Doppler velocimeter)
temperature bound. condition	measured (HOBO instream temperature logger)
groundwater inflow	estimated through calibration
hyporheic exchange	estimated through calibration

[a] In heavily vegetated areas, along streams in steep canyons, or when very fine scale variations in slope are required, digital elevation model (DEM) data may not provide a sufficiently accurate estimation of slope. Methods used here to determine slope can be found on pages 140 and 149 of ref 10.

($\Phi_{convection}$) is driven by air convection above the stream and is directly related to the stream–air temperature gradient. The latent heat flux (Φ_{evap}) is a result of evaporation from the stream surface and is calculated with the mass transfer approach based on the water vapor pressure gradient and a wind function. To solve eq 1, input data were specified at 2 m intervals, and computations were performed with a 5 m discretization and a 1 min time step.

We modified the model components that calculate heat fluxes due to groundwater flow (Φ_{gw}) and hyporheic exchanges (Φ_{hyp}). We specified the hyporheic flux rate (q_{hyp}) as a volumetric flux per unit length of stream, [m^2/s]. The heat flux to/from the stream was then calculated as

$$\Phi_{hyp} = \frac{(T_{hyp} - T_s)q_{hyp}\rho C_p}{W} \quad (2)$$

where T_{hyp} is the hyporheic zone temperature. The hyporheic zone is assumed to have the same dimensions and temperature as the conductive layer. The hyporheic zone/conductive layer temperature is modeled by summing the streambed conduction and hyporheic heat fluxes to this zone and calculating the temperature change based on this zone's volume and heat capacity. This modification overcame the inherent difficulty in estimating mass exchange from hydraulic conductivity and hydraulic head gradient estimates. In addition, we better accounted for the heat flux of groundwater inflow (Φ_{gw}) as

$$\Phi_{gw} = \frac{(T_{gw})q_{gw}\rho C_p}{W} \quad (3)$$

where the groundwater inflow (q_{gw}) is the volumetric flux per unit length of the stream, and T_{gw} is the groundwater temperature. This was necessary because the effect of groundwater inflow on stream temperature was previously calculated using a simple, flow-weighted mixing model, which failed to represent the effect of groundwater inflow when small time steps were used.

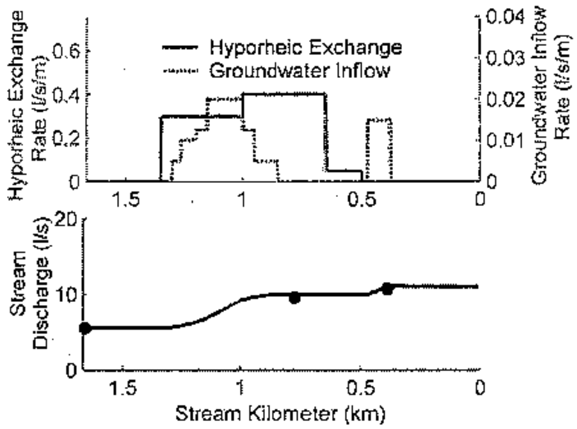

FIGURE 3. Distribution of groundwater inflow and hyporheic exchange, which resulted in the best-fit between the observed and simulated stream temperatures. Where the hyporheic exchange rates are 0.05, 0.3, and 0.4 L/s/m, the depths of the hyporheic zone are 0.25, 0.30, and 0.45 m, respectively. The lower graph shows measured and modeled stream discharge for the cases that include groundwater inflow.

The data requirements and sources are summarized in Table 1. The rates of groundwater inflow and hyporheic exchange and the spatial distribution of these fluxes were varied manually until the best-fit between the modeled and observed T_s was obtained. To evaluate the goodness of fit, we simultaneously compared the diurnal temperature patterns (instream HOBO) and the longitudinal temperature profiles (FLIR) to the model results using both visual inspection and root-mean-square residuals (RMSRs). Three additional cases are considered to demonstrate the effect that groundwater inflow and hyporheic exchanges have on T_s. The best-fit model will be called the "base case" (Figure 3). The second case (No Hyp) is the base case but with no hyporheic exchanges. The third case (No GW) is the base case but neglects all groundwater inflow. The last case (No GW and No Hyp) assumes that there is neither groundwater inflow nor hyporheic exchange anywhere within the reach.

Results and Discussion

Data collected from thermal imagery and instream data loggers are shown in Figures 4 and 5. FLIR-based T_s estimates correlate well with values recorded instream ($R^2 = 0.96$). The mean absolute difference between the two types of data was 0.55 °C (K). The longitudinal profiles demonstrate that heat exchange processes throughout the reach change quite rapidly over space.

The average width and depth of this stream reach are 1.6 ± 0.7 and 0.23 ± 0.18 m, respectively. For discussion purposes, the meadow will be separated into three subreaches: the upper (km 1.67–1.35), middle (km 1.35–0.65), and lower (km 0.65–0). The middle subreach is the zone most directly affected by restoration efforts. In the color infrared image that serves as a base map for Figure 1, riparian vegetation in the middle subreach appears red because the region is dominated by lush mesic vegetation such as sedges and rushes, which indicate a shallow water table. The upper and lower reaches are outside the direct zone of influence of restoration and contain a mix of dryland grasses and sagebrush, which appear blue in the color infrared image. The upper-reach streambed is often intact bedrock or bedrock covered with a thin layer of gravel. The lower-reach streambed is composed of either fine-grained silts or bedrock. Through the middle subreach, the channel was constructed by

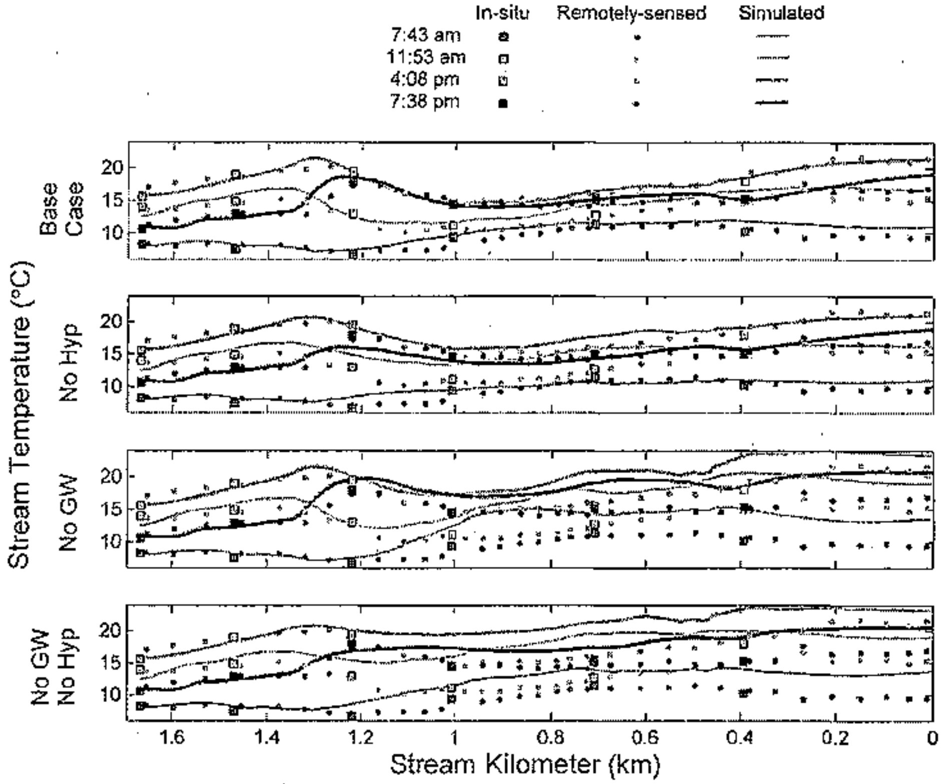

FIGURE 4. Comparison of observed in situ (HOBO) and remotely sensed (FLIR) T_s with simulated longitudinal profiles of T_s. Streamflow is from stream kilometer 1.67 to 0.0 (left to right). The RMSR for the four cases (Base Case, No Hyp, No GW, and No GW−No Hyp) are 1.1, 1.4, 3.3, and 3.5 K, respectively.

excavating the silty meadow soils, which contain zones of sand and gravel. Since channel construction in 1995, sand and gravel have been deposited within the channel both naturally and during restoration. In addition, riprap riffle structures have been added to stabilize the channel and create pools, which raise the elevation of the stream surface. These coarse-grained materials appear to act as important stream−aquifer exchange zones.

Depressed river temperatures indicate streamflow contributions by groundwater (baseflow) and/or hyporheic exchanges. During early June, T_s (~7−19 °C) is generally greater than the relatively constant groundwater temperature (~7 ± 0.8 °C). Thus, groundwater inflow within a reach will have a cooling effect on the longitudinal T_s profile either causing T_s to decrease through the reach, or causing T_s to increase to a lesser extent than it would in the absence of baseflow. The effect of groundwater inflow on the longitudinal T_s profile is greater in the afternoon since the temperature difference between the stream and the groundwater is greatest at this time. Hyporheic flows have a buffering effect on T_s in that they tend to cool the stream at times when T_s is rising, but they warm the stream when it is cooling (*17*). Hyporheic buffering causes suppressed T_s maxima, increased minima, and a time lag in the occurrence of stream temperature extrema. The time lag in peak T_s results from the time needed to heat the water and sediments of the hyporheic zone, which are engaged in active heat exchange with the stream.

In both the upper and lower subreaches, T_s increases rapidly in both space (Figure 4) and time (Figure 5) from sunrise until early afternoon as water flows through these reaches. Compared to the upper and lower subreaches, in the middle subreach T_s is buffered and reaches a lower daily maximum, which occurs later in the day. In fact, at sites 1, 2, 3, 4, 5, and 6, the maximum stream temperatures are 16.3, 19.2, 19.9, 14.8, 15.8, and 18.1 °C, occurring at 2:15, 3:30, 5:00, 5:15, 5:45, and 3:30 pm, respectively. The timing and magnitude of these temperature maxima reflect the heat exchange mechanisms occurring at and upstream of these sites; these observations suggest increased baseflow and hyporheic exchange within the middle subreach.

Higher rates of groundwater inflow and hyporheic exchange cause the afternoon dip in the T_s profile (Figure 5) through the middle subreach. Maximum daily T_s in the upper reach (sites 1 and 2) and the lower reach (site 6) are fully 2−3 degrees higher than those in the middle reach (sites 4 and 5), a result primarily of the cooling influence of inflowing groundwater. Yet, hyporheic exchange also contributes to the lower T_s by moderating daily T_s extremes. A more diagnostic effect of increased hyporheic exchange is that the maximum T_s occurs ~2 h later in the middle subreach versus the other subreaches. This effect is seen in the temporal data (Figure 5) by comparing the observed diurnal temperature records at sites 1, 2, and 6 with the muted and lagged patterns observed at sites 4 and 5. The diurnal temperature record at site 3 (just downstream of the transition into the restored reach) has a high maximum because of the influence of the upper reach, yet also experiences a significant lag caused by a high rate of hyporheic exchange immediately upstream. This hyporheic exchange retards heat advection.

Simulating T_s and heat exchange processes provided quantitative estimates of groundwater contributions to streamflow and hyporheic exchange rates. These fluxes were determined by varying groundwater inflow rates, hyporheic exchange rates, hyporheic zone depth, and the distribution of these fluxes until the simulated temperatures matched the observed spatial and temporal T_s data. The matches were compared using the RMSR (see captions of Figures 4 and 5). The best-fit model was obtained using the groundwater inflow and exchange rates in Figure 3. The RMSR between the

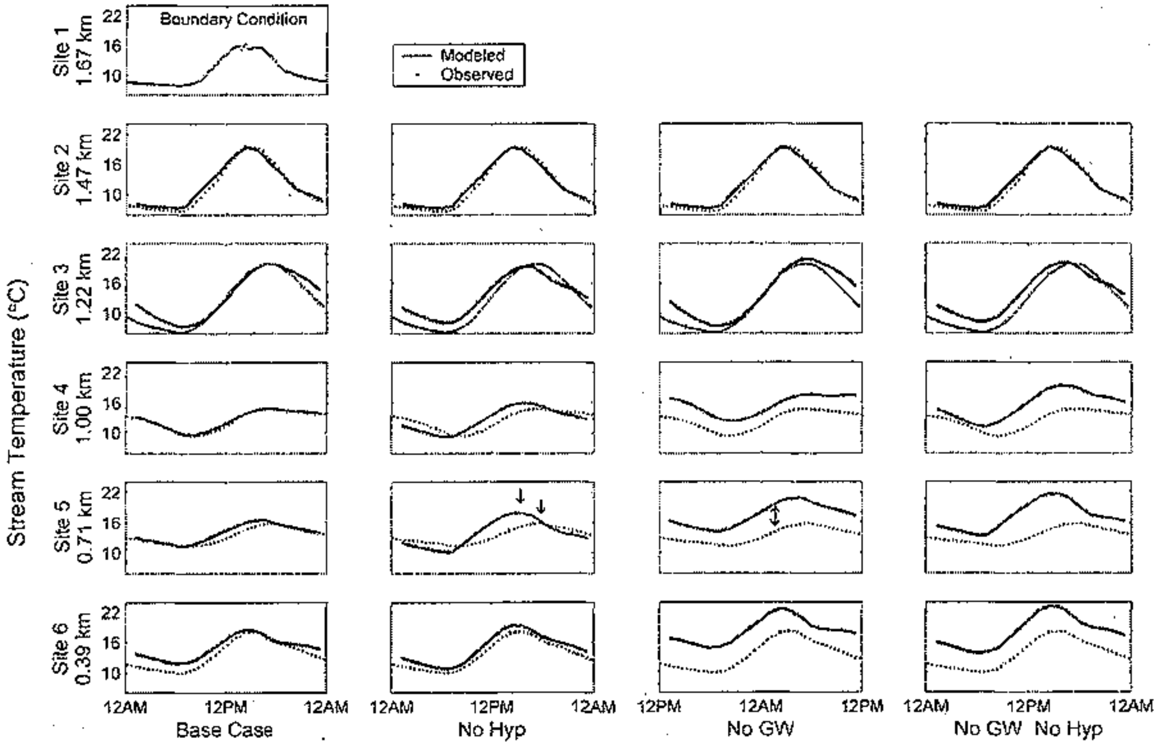

FIGURE 5. Simulated and observed diurnal records of T_s at the locations of the instream temperature loggers for the four cases. Data from Site 1 was used as the upstream boundary condition. The RMSR for the data at the other five sites for the Base, No Hyp, No GW, and No GW—No Hyp cases are 1.1, 1.4, 3.2, and 3.2 K, respectively. The two downward arrows highlight the discrepancy between the modeled and observed times of maximum T_s when hyporheic flow is neglected. The double-ended arrow emphasizes that T_s is overpredicted when groundwater inflow is neglected.

simulated T_s and the FLIR longitudinal profiles is 1.1 K. The RMSR between the simulated T_s and the HOBO-recorded diurnal T_s patterns is also 1.1 K. Checking against the independent measurement of groundwater contributions obtained with synoptic stream gaging (Figure 3), we note that the increase in streamflow attributed to groundwater inflow as determined here agrees with the spatially integrated values provided by gaging. Streamflow measured at the upper, middle, and lower stream gage sites were 0.0055, 0.0095, and 0.0107 m^3/s, respectively; modeled values were 0.0055, 0.0099, and 0.0108 m^3/s, respectively.

When hyporheic exchange is neglected, less buffering of T_s occurs, and the RMSR increases by 0.3 °C (K) for both the longitudinal (Figure 4) and temporal (Figure 5) data sets. A large discrepancy occurs at site 5 in the No Hyp case (Figure 5) because the temperature record at this site is strongly affected by heat exchange processes occurring immediately upstream in the middle subreach, where neglecting hyporheic exchanges has the greatest impact. Neglecting hyporheic exchanges causes the temperature maximum to be over-predicted by 2.0 °C (K) and to occur 2.5 h earlier in the day in the downstream portion of the middle subreach (site 5).

When groundwater inflow is neglected, simulated T_s is too high in the middle and lower subreaches, with the cumulative error becoming more severe downstream. In this case, the RMSR increases by over 2 °C or K (200%) compared to the base case. It is noteworthy that this case also demonstrates that T_s maxima at some locations would be over 4 °C (K) higher without the cooling effect of the inflowing groundwater. Similarly, when both groundwater inflow and hyporheic exchange are neglected, simulated T_s is too high, the amplitude of diurnal temperature variations is too large, and the peak T_s occurs too early. With neither the buffering effect of hyporheic exchange nor the cooling effect of baseflow, the daily maximum T_s is more than 5 °C (K) higher than that in the base case.

These results demonstrate the importance of groundwater inflow and hyporheic exchange in creating stream reaches with thermal regimes that are capable of supporting fisheries. In fact, on the day these data were collected, the stream reach from kilometer 0.6 to 1.2 provided good habitat for rainbow trout (*Oncorhynchus mykiss*) and other cool water species because of the lower daily T_s maximum, whereas the reaches above and below are of marginal quality (*3, 11, 18*).

In summary, hyporheic fluxes cause a time lag and a buffering of T_s, whereas groundwater fluxes result in a depression in T_s; the differing responses of these processes reduced the problem of nonuniqueness, which facilitated manual calibration of the model and determination of these fluxes. While this manual fitting procedure is subjective, time-consuming, and requires a thorough understanding of the processes affecting T_s, it forces the analyst's intimate contact with the model, (1) helping to maintain parameter values within reasonable ranges for the stream reach, (2) allowing inclusion of "soft data" (e.g., location of hydric vegetation communities or seepage faces), that have been observed in the field, and (3) providing a clear understanding of the sensitivity of the model to its parameters.

Model-based estimating of hyporheic exchange is confounded by the fact that three separate processes can have a similar buffering effect on T_s. First, heat is carried by water flowing between the stream and the hyporheic zone. Second, heat is transferred from the flowing portion of the stream to "stagnant zones" of surface water within the stream channel. Third, heat is conducted between the stream and the subsurface sediment. In all three cases, heat is exchanged between the flowing streamwater and its surroundings (hyporheic zone, stagnant zones, and streambed conduction layer). In experiments, Gooseff et al. (*19*) observed differences in late time tailing of introduced stream tracers. They believe that these differences can be used to distinguish between the first two processes. Runkel (*20*) and others have successfully modeled the first two of these processes by considering them together as a lumped transient storage mechanism for solutes. For heat transport in streams, the third process (streambed conduction) also influences T_s in the same manner as hyporheic and stagnant zone exchange. Because all of these processes can have nearly equivalent effects on T_s, differentiating between them using stream-temperature data alone is difficult. Thus, estimated hyporheic exchange rates may not represent hyporheic exchange alone and are likely overpredicted because they also represent heat exchange between the flowing-stream and stagnant-water zones within the channel. This is a specific example of a general concern. Error can creep into any approach that estimates flux magnitudes by simulating a response variable that is dependent on many processes; conceptual model error or uncertainty of input parameters may lead to inaccuracies of fitted parameters.

In Cottonwood Creek, groundwater inflow caused significant cooling in the restored stream reach, which was a goal of the restoration efforts. Synoptic streamflow measurements verified that groundwater inflow (baseflow) rates estimated using FLIR thermography were accurate within 10% in this application. Later in the season, streamflow decreased to zero at the upper end of the reach; however, for several weeks afterward, streamflow began between kilometers 1.0 and 1.3, which is consistent with the presence of the identified groundwater inflow zone. Furthermore, hyporheic exchange (and perhaps "stagnant zone" exchange) is shown to increase the buffering effect on T_s within the restored reach. Much of this exchange is probably a result of high conductivity riffles made of 10 cm clasts added to create pools and prevent erosion. The riffles are highly transmissive, and, at lower streamflow, all of the discharge has been observed to flow through the riffle structure, suggesting that high exchange rates are realistic. These results indicate that hydrologic function differs significantly between restored and adjacent subreaches. The increased baseflow and hyporheic exchange create a thermal regime that improves the aquatic habitat potential of the restored subreach.

Remotely sensed profiles of T_s have been combined with in situ diurnal records of T_s to gain insight into the subsurface flow system. The spatial coverage provided by the remotely sensed data enabled pinpointing abrupt changes in heat exchange and quantifying a spatially continuous baseflow contribution profile. The instream diurnal records of T_s validated the remotely sensed data and provided a continuous, temporal dataset that was used to help match the diurnal temperature cycle. Using a physically based, energy budget model, these rich data sets were used to quantify subsurface groundwater inflow and hyporheic exchanges at a restoration site where exchange rates are high relative to the streamflow. We feel the largest obstacle to scaling up this method is that the ratio of groundwater inflow and hyporheic exchange to streamflow decreases as the scale of the watershed increases. This reduces the sensitivity of the method but may be counteracted by collecting data under low-flow conditions when stream−aquifer interactions are relatively more significant. Future research should address whether this type of approach can be useful for quantifying stream−aquifer interactions at larger (watershed) scales.

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Project 2105 EIR Scoping Comments

Watershed Restoration and Improvement Alternative

Introduction

The County of Plumas requests that the State Board analyze the Watershed Restoration and Improvement Alternative ("Watershed Alternative") presented below as part of the EIR for the water quality certification for FERC Project 2105. The Watershed Alternative provides for off-site mitigation in the East Branch of the North Fork Feather River, where mitigation benefits can be achieved in greater magnitude, at less cost, and without the redirected impacts of many of the mitigation alternatives being proposed within the Project 2105 boundary. Mitigation opportunities in the East Branch can produce water temperature and other water quality benefits in the North Fork and provide attendant habitat improvements – all in ways that are consistent with regional water management plans. The Watershed Alternative is offered as a stand-alone alternative or to be used in combination with other prudent alternatives.

Plumas County has a longstanding commitment to improving the economic and environmental health of the Upper Feather River watershed – more than seventy percent of which lies within the County's jurisdiction – for the benefit of County residents and visitors and for more distant beneficiaries. Plumas County has consistently advocated a collaborative and watershed-based approach for balancing beneficial uses in the North Fork Feather River. As stated in the Integrated Regional Water Management Plan for the Upper Feather River:

> *It is apparent to most decision-makers in the watershed that piecemeal planning constrains the range of potential solutions to the region's most pressing conflicts. By building on the wealth of hands-on watershed restoration experience, project-scale monitoring, and institutional capacity it will become possible to expand water management and planning to larger scales when water management conflicts require larger scale solutions.*

In the context of the relicensing of FERC Project 2105 and the management of the North Fork, Plumas County opposes solutions to certain water temperature and fishery problems, such as the thermal curtain in Lake Almanor, that provide limited benefits in one area while potentially harming our citizens' quality of life and negatively impacting our environment and recreation-based economy elsewhere.

Based on preliminary review of a number of proposals that attempt to reduce water temperatures in the North Fork, it is evident that a great deal of money could be spent without producing significant benefits. Even under some of the most ambitious proposals, it appears there will be periods of time when it is impossible to meet 20°C temperature standards in the North Fork Feather River (NFFR) without significantly diminishing the cold water pool and degrading the cold water fisheries in Lake Almanor and Butt Valley Reservoir. There may even be periods of time when it is impossible to meet cold water temperatures in the NFFR without causing seasonal harm to the fishery in the Seneca reach.

Instead, other alternatives may provide comparable downstream benefits with more adaptive management flexibility and fewer redirected impacts. From a review of currently available data, three degrees of coldwater improvements in the Rock Creek/Cresta Reach of the NFFR in normal water years may be achieved in a number of ways. In particular, the East Branch of the North Fork is a significant source of hot water for the river and presents a mitigation opportunity for the North Fork system that is begging to be seized. For that reason, Plumas County is proposing the Watershed Alternative for off-site, compensatory mitigation in the East Branch, as detailed in the following pages.

Watershed Alternative

After extensive review and years of participation in the collaborative licensing processes, Plumas County has concluded that off-site mitigation is the most feasible and effective way to address the irreversible and continuing loss of coldwater habitat for trout resulting from hydro-modification of the NFFR system. Trout have lost access to historic coldwater refugia and spawning habitat in the main channel and the tributary streams of the NFFR. These impacts are permanent and cannot be adequately mitigated by any practical means. PG&E's hydroelectric dams block trout from migrating up and down the NFFR to seek suitable coldwater habitat. Without fish ladders, the continuing blockage of fish passage cannot be mitigated on-site, in the NFFR. Creating further detriment, the Rock Creek, Cresta and Poe reservoirs warm NFFR water beyond temperatures that would have occurred under free flowing river conditions.

Plumas County supports efforts by the Department of Fish and Game, the Plumas National Forest, the 1962 ERC, and others who are working to improve fish spawning habitat and coldwater conditions and other protections (such as increased warden presence) for the improvement of the coldwater fishery in the NFFR Canyon. To complement those efforts, Plumas County proposes the Watershed Alternative - offsite compensatory mitigation for 2105 and the cumulative impacts of the other PG&E projects on the North Fork. The Watershed Alternative is offered as a stand-alone alternative or to be used in combination with other alternatives.

The Watershed Alternative confronts the dilemma of incremental improvements in water quality and the coldwater fishery in the NFFR being achievable only by degrading the coldwater fishery and summer water quality in Lake Almanor. The Basin Plan's designated beneficial uses for Lake Almanor should not be impaired by efforts to improve preexisting conditions in the NFFR – conditions that have existed for nearly a century and that pre-date State Board Resolution 68-16 and the federal Clean Water Act by more than 50 years.

Instead, the Watershed Alternative should be used to improve stream reaches elsewhere in the North Fork watershed as off-site, compensatory mitigation for not achieving the last marginal and costly increments of coldwater fishery and temperature improvements in the NFFR. Plumas County supports improving coldwater fisheries and summer water quality throughout the North Fork system, including Lake Almanor and Butt Valley Reservoir. However, degrading Lake Almanor for a final increment of benefit in the NFFR is not "worth it" at any price, even if such a trade-off is technically feasible.

The Watershed Alternative was initially set forth in an August 1, 2005, document prepared for the 2105 Licensing Group collaborative. The latest version of the document is attached as Appendix A and includes a detailed description of Plumas County's proposed projects and their estimated costs and benefits. The following sections of this document further describe aspects of the 17 proposed restoration projects in four subwatersheds of the East Branch of the North Fork, including their environmental benefits and the linkages to Project 2105.

Watershed Alternative and NOP Feasibility Criteria

The State Board's Notice of Preparation (NOP) for the EIR sets forth criteria for evaluating the feasibility of alternatives, and that evaluation will inform the decision on which alternatives to include and analyze in the EIR. The sections below address aspects of the Watershed Alternative in the context of the evaluation criteria stated in the NOP.

Temperature Moderating Benefits to the Affected NFFR Reaches

The entire Watershed Alternative is based upon the premise that for any given level of effort and expenditure, temperature benefits and corresponding habitat improvements can be achieved in a much greater magnitude in the vast, free-flowing expanses of the East Branch of the North Fork than in the highly modified and flow-controlled reaches of the river system from Canyon Dam to Bid Bend. Therefore, the Watershed Alternative does not directly affect temperature in the reaches from Canyon Dam to the confluence with the East Branch, but it does provide significant compensatory benefits in the East Branch as well as some benefit in the North Fork below the confluence.

The North Fork canyon within the 2105 project boundary is unique, and there are no comparable mitigation opportunities in the region. However, within the larger North Fork system, there are canyon stream reaches in the East Branch that are comparable to the river sections within the 2105 boundary, although they are smaller and interspersed with alluvial valleys. Degraded conditions in those valleys provide mitigation opportunities that will improve water quality and biological connectivity in the canyon reaches. Given the biological and hydrological connection between the North Fork and its East Branch, the EIR analysis should include the potential for mitigation of cumulative effects in the watershed through off-site mitigation.

Jim Wilcox is the Program Manager for the Feather River Coordinated Resource Management Group. In his professional judgment, which is based on 20 years of watershed restoration experience in the Upper Feather River Basin, full implementation of the Watershed Alternative would delay the onset of temperature exceedances in the NFFR by two weeks in a normal year and provide water temperature improvement throughout the summer. Although the East Branch contributes a relatively small portion of the total North Fork summer flow, it is a significant source of hot water. Unlike the river reaches from Canyon Dam to Big Bend, there are numerous opportunities in the East Branch system for the restoration of natural conditions and processes that will in turn reduce hot water. If Project 2105 is operated at historic capacity from mid-July through August, the temperature influence of the East Branch is minimal, but that influence increases commensurately with any reductions in power production.

Cost of Implementation Versus Predicted Benefits

Based on PG&E's 4-D report, a two-week delay in the need to reoperate the 2105 hydro-electric system at Lake Almanor, Butt Valley Reservoir, and Belden equates to an avoided cost of about $1 million per year that would otherwise be lost in power generation in the month of July. Depending on the term of the new license, savings would be on the order of $30 to $50 million in today's dollars. The Watershed Alternative is estimated to cost $30 million over the same period, and Plumas County proposes to augment PG&E's contributions with funds from other sources. Therefore, the Watershed Alternative warrants analysis for cost reasons alone.

In contrast to the other temperature modification alternatives under consideration, the benefits of the Watershed Alternative are realized year-round and provide much broader environmental enhancements. The Watershed Alternative improves habitat for riparian, wetland, and aquatic species on 80 stream miles of the East Branch and provides meadow floodplain restoration to 6,000 acres. In comparison, there are less than 40 stream miles in the main stem of the North Fork.

Implementing the Watershed Alternative in combination with reasonable and feasible temperature modification measures in the NFFR Canyon addresses up to three times more riverine and coldwater fish habitat than a "no project" alternative. Improving up to 120 miles of river in the main stem and the East Branch can enhance biological connectivity in the whole North Fork system – which is one of the goals of the Integrated Regional Water Management Plan for the Upper Feather River.

Incidental Environmental Effects

The local Feather River Coordinated Resource Management Group (Feather River CRM) has implemented over 40 stream bank erosion control and meadow re-watering projects since 1985 on public and private lands in the Upper Feather River Basin. Project monitoring combined with modeling-based predictions (Linda Bond, 1997; Rick Kattlemen, 1987) suggest that meadow and stream restoration in combination with upland vegetation management could reduce downstream flood peaks by five percent for the first 24 to 36 hours of a severe winter storm, while enhancing summer base flows by seven percent. Measurements of flood events (when possible) have shown that 50 cfs discharges in channels are associated with 5cfs flows on adjoining floodplains during the same flood period (Kossow-Cawley, 1987). Dr. Bond estimates that restoring groundwater storage in the 200,000 acres of degraded meadows in the Upper Feather River Basin would increase late season surface water yields by 100,000 or more acre feet in normal and wet years. In 1999, Dr. Jeff Romm, an economist at UC Berkley, conducted a cursory survey of the value of restoring natural watershed processes in the Feather River watershed and concluded that "in certain conditions, riparian and meadow restoration can actually enhance water storage more efficiently than dam augmentation."

Based on professional judgment by the FR-CRM staff and based on data that has been collected by the FR-CRM (see Appendix A), the Watershed Alternative could mitigate water temperatures by 3°C to 9°C or more in June, July, and August in specific stream reaches of the East Branch.

When compared to other temperature modification alternatives under consideration by the State Board, the Watershed Alternative could provide as much as three times the peak stream temperature mitigation, depending on the characteristics of particular stream reaches in the East Branch. In most cases, water temperatures of 20°C could be achieved in June, July, and August of normal years within 10 years of initiating restoration treatments. PG&E's July, 2005, 4-D report states that trout useable wetted habitat would increase by an average of about 5 percent and a maximum of about 15 percent in the NFFR as a result of a variety of temperature modification alternative measures. We recognize that these estimates are preliminary and may be revised upward. We predict that the Watershed Alternative will increase trout habitat by 10 percent to 30 percent or more, as measured by the National Forest Stream Condition Inventory (SCI) protocol. (See Appendix C for more information on the SCI protocol).

Scientific Basis for Watershed Improvement Alternative

Watershed-wide erosion identified in a 1989 study conducted by the Soil Conservation Service (now called the Natural Resources Conservation Service) is one symptom of an overall loss of watershed function. Other symptoms include increased flood peaks and flood damage frequency, water quality impairments (nutrients and temperature, as well as sediment), and the ongoing loss of aquatic and terrestrial habitats. The primary physical process resulting in these symptoms is channel incision in the meadows and valleys of the upper two-thirds of the watershed (Clifton, 1994). Once initiated, incision/stream bank erosion continues until a new channel base level is reached. On many of the larger channel systems this erosion and channel widening and deepening process has reached depths of 14 to 16 feet and widths of 300 feet or more, far beyond the range of natural with/depth ratios in healthy streams. The incised channel continues widening by eroding the stream banks below the protective rooting depth of the native meadow sod. As the incising channel capacity increases more stream flow is captured, further severing the stream from the naturally evolved flood plain. In many areas of the watershed virtually no flood flows now access the historic flood plains. The concentration of stream flows and the desertification of the original riparian vegetation community further weakens stream banks, creating ongoing cycles of erosion, dewatered meadow aquifers, peak summer heating temperatures, and the continued loss of coldwater fish habitat.

After the winter precipitation and runoff season ends, surface water flow derives almost entirely (80% or more) from groundwater and tributary flows (Benoit). In healthy systems, fully recharged groundwater aquifers feed surface flows throughout the summer. Some models estimate that shallow meadows completely drain groundwater into streams in one to three year's time, depending on each previous year's precipitation (Loheide). Mature riparian and aquatic vegetation, and defined and self-maintaining pools and riffles (ideally at a 1:1 ratio), maintain cooler stream temperatures and provide cold water refugia for fish, even during prolonged peak heating spells during the four to five month summer droughts that are common to this watershed.

Project-Level Impacts of Restoring Watershed Function to East Branch Streams

The Indian Creek Watershed Study (Soil Conservation Service, 1993, pp. 37-38) predicts a 2.3°F reduction in summer stream temperatures from a 25 percent increase in riparian shading and a 3.9°F decrease in summer stream temperatures from a combination of 25 percent increase in riparian cover and a 50 percent decrease in stream width in Indian and Genesee Valleys. Genesee and Indian Valleys are the largest and lowest elevation valleys in the East Branch. Other experts have documented 2 to 4 or more degrees F cooler water in stream pool bottoms (Flint, Theiss, Kavvas: personal communications). A possible outcome from successful stream rehabilitation could be as much as 8-15° F cooling of stream waters at the bottoms of pools three feet and deeper that are overhung by at least 25 percent riparian vegetation. This outcome would be achievable within 10 years, depending on vegetation recovery and post-project vegetative management. As an example, monitoring of the recently completed Last Chance Creek meadow rewatering and stream rehabilitation project has documented a 10°F reduction in stream temperatures from the top of the project area to the downstream end of the project (4 miles) in June 2004, the first year after reconstruction (Wilcox).

Reconnecting restored stream channels to re-watered floodplains would add longer influxes of 50° to 58°F groundwater to summer baseflows, with an unknown but potentially significant additional cooling downstream. The 1994 project at Big Flat demonstrated a 30-day extension of perennial flow in ephemeral Cottonwood Creek from groundwater accretion after completion of the project. Groundwater temperatures in the gravels in the rewatered reach were 50° to 58° F (Wilcox, Seagraves). The Big Flat project on one mile of Cottonwood Creek produced a trout increase of 1,000 rainbow trout per mile, post-project, compared to zero trout per mile in the pre-project condition (Mink). This project achieved such dramatic gains in coldwater fishery populations through a combination of habitat and water quality improvements. A low width (2-4')-depth (4'-6') sinuous channel with undercut banks was constructed and the 47-acre adjoining floodplain was re-watered. Groundwater inflow from uplands and the adjoining meadow was reconnected to the stream channel so that groundwater accretion to the channel was prolonged. Stream temperatures were maintained by the low width-depth ratio. Wetland vegetation development in combination with grazing management has improved coldwater trout habitat during a longer period of the summer (Mink).

In the "Red Clover Demonstration Project Research Summary Report (1985-1995)", the following information is presented. "These results show that substantial heating of the stream occurs upstream of the demonstration area. They also show that the ponds were deep enough to provide pockets of water that were considerably cooler .... 20°C was exceeded 71-98% of the days near the surface of the pond (3 foot depth) compared to 0-55% of the days at the bottom (8 foot depth). Exceedance of 22°C near the surface occurred on 31-74% of the days compared to 0-16% at the bottom of the pond." Surface stream temperatures upstream of the project reached 27.5°C and 29.7°C during the same July-August, 1989-1993 period. And it is important to note that the ponds were completely unshaded. The authors conclude that "Lowering water temperatures throughout Red Clover Creek would require substantial channel narrowing and development of riparian cover, possibly in combination with increased base flows from groundwater" (Seagraves, 1995, pp. 8-10).

In the Red Clover Demonstration Project, as in the NFFR, lack of spawning habitat, intense competition for coldwater refugia (with non-game fish species), and selective predation (including poaching) are important causes of decreased rainbow trout abundance and reproductive success, along with water temperatures. Lack of spawning habitat in the Red Clover Project led directly to the innovative "pond and plug" meadow rewatering design as an alternative to traditional instream check dam installations. As the now-preferred way to rewater meadows and to reconnect streams and floodplains, "pond and plug" restoration treatments plug the eroding gully with fill collected from off-stream pond development. A small narrow sinuous stream channel is allowed to develop, or is reconstructed, on top of the re-watered and pond filled floodplain. In this way, pool-riffle stream features are reestablished and spawning habitat is enhanced because ponds do not replace free flowing streams, as they do in instream check dam designs. Instead, off-stream ponds replace the old gullies, and a free-flowing stream redevelops down the low point of the meadow.

Project Prioritization in the Watershed Alternative

According to a recent report from the State Board:

> Much of the upper Feather River watershed has been affected by 140 years of intensive human use. Mining, grazing, timber harvesting, wildfire, and railroad and road construction have all contributed to watershed degradation, which is down cutting and widening of tributary streams, causing erosion/sedimentation, increased water temperature, and other adverse impacts on water quality, fisheries, and aquatic habitat.
>
> Watershed Management Initiative, State of the Watersheds Report, Feather River Subwatershed, 2002, pp. 10-14.

All of the proposed project areas in the Watershed Alternative exhibit the legacy watershed degradation attributes described by the State Board. The following conceptual framework is the scientific basis for the project prioritization that is presented in the tables in Appendix A:

- Inadequate cold water in lakes and streams limits water quality in the summer and fall.
- Excessive stream bank and road-related erosion from flood flows limits water quality during the winter and spring.
- Restoring groundwater recharge through enhancing floodplain and flood-way processes lessens erosive flood forces in stream channels.
- Restoring groundwater recharge in meadows and forested uplands prolongs base flows in streams through enhanced groundwater influxes to streams during the summer-fall drought.
- Integrating surface water and groundwater management for better drought and flood management provides an opportunity to increase cold water in lakes and streams during the summer-fall drought period.

<u>Priority 1</u> projects are mostly "meadow re-watering projects" which means that the project includes reconnecting the stream to its natural meadow floodplain and to the groundwater aquifer that is associated with the historic meadow-floodplain. Priority 1 meadow re-watering projects create significant seasonal and permanent wetland habitat and recreate summer-long groundwater influxes to streams as rewatered aquifers naturally drain downslope and downstream during the summer-long drought. Because groundwater temperatures range from 50° to 58° F, floodplain aquifers provide a significant source of cooler summer water to streams both within and downstream of a restored stream reach.

Priority 2 projects are mostly "geomorphic reconstruction projects" that are installed in confined, eroding stream channels with narrow floodplains that have formed within eroding gullies in meadows. For a variety of reasons, it is no longer feasible to reconnect the stream to its historic floodplain meadow. Rehabilitation of the stream and riparian system must be confined within the eroding gully. Rehabilitation work in stream systems that are unconnected to their historic meadows and floodplains is inherently more risky than work in natural stream and floodplain-meadow systems. Entrenched or incised streams, as they are called, carry larger volumes of floodwaters within their stream channels rather than spreading higher flood flows across wide floodplain meadows. Concentrating flood flows within a narrower cross-sectional area of the erosion-caused gully exponentially increases the erosive force of flood waters. In addition, streambank vegetation in entrenched or incised channels tends to be less vigorous, because incised channels are more isolated from groundwater inflows during the summer growing season. More stream power combined with weaker vegetative protection creates the potential for higher failure risks and longer recovery times for incised streams.

Restoration projects have generally been implemented in a downstream direction from the headwaters, so that the benefits from upstream projects accrue to future projects downstream. Downstream, the stream systems and alluvial valleys become larger, and current watershed stresses such as urbanization, water diversions, stream channelization, and flood control become larger factors in restoration designs. The rehabilitation of the upstream watershed has the potential to help seed lower river reaches with excess productivity from increased populations of the macroinvertebrate, fishery and riparian communities. During the months of primary water temperature concern (July and August), the restored reaches upstream could act as areas of refuge along with the cooler tributary streams.

The tables in Attachment 3 summarize the Watershed Alternative in as much detail as is available at this time. The Priority 1 reaches identified are located in three subwatersheds: Last Chance, Red Clover, and Indian Creeks. Last Chance and Red Clover are at the upper end of the East Branch watershed. Lower Indian Creek is the next subwatershed downstream. The Priority 1 reaches vary from one to ten stream miles in length, and include 70 to 1,000 acres of adjoining meadow-floodplain. The Priority 2 reaches are located in the Spanish Creek and upper Indian Creek subwatersheds. These reaches vary from three to seven miles in length and affect 90 to 1,000 acres of floodplain and meadow. Water from each of these reaches eventually flows into the East Branch and North Fork Feather River.

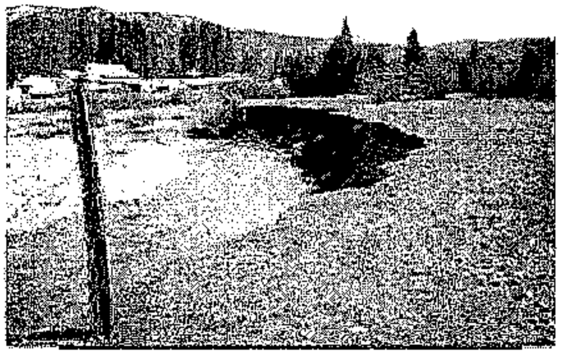
Project Risks and Benefits

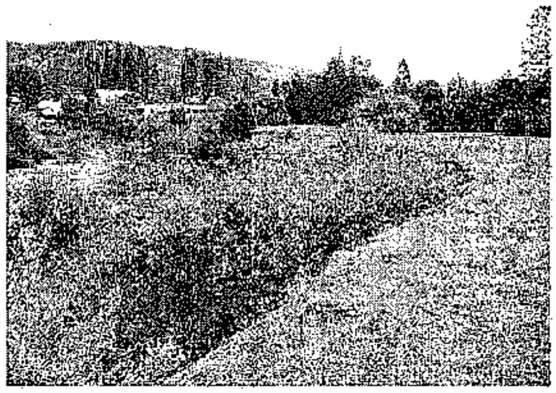
In the best of circumstances, benefits can be fully realized in three to five years in meadow re-watering projects of unconfined systems (Priority 1) and in eight to ten years in confined stream reaches (Priority 2). The duration of benefits is probably up to a 45-year magnitude flood event for mature Priority 2 projects in confined systems, and may be up to a 75-year or greater magnitude flood event for mature Priority 1 projects in unconfined stream systems.

The timing of benefits and costs is most dependent on the time interval between project implementation and the next peak flood event and whether the treated stream is entrenched or unconfined and grazed or ungrazed. A 100-year flood occurring in the first runoff season after the installation of a Priority 2 project in a confined system creates a risk of significant damage because vegetation has not had enough time to become established. Priority 1 unconfined systems, protected by the energy dispersal of the floodplain, have a much lower (10%-20%) risk of substantial damage from a 100-year flood in the first year after construction and revegetation.

Whether a peak flood event is the last high flow event of a runoff season or the first event in a series of high water events in a season also affects the risks for damages in any given year. If a project has the next summer growing season to recover from the damage of the last winter flood event, there will be less risk of damage from future flood events. For example, the Wolf Creek geomorphic reconstruction project in Greenville, which was constructed in 1989, has demonstrated that vanes are a streambank treatment in confined systems that were capable of withstanding the 1997 flood velocities eight years after construction and revegetation. Pre and post-project photos are presented below.

Wolf Creek Vane Project





As a final note, the predicted benefits presented in Appendix A are based on the professional judgment of the FR-CRM staff. The FR-CRM and its subcontractors include professional hydrologists, fishery and wildlife biologists, botanists, and soil scientists with decades of professional experience in the upper Feather River Basin. Monitoring data reflects the project priorities and performance criteria for individual projects. Early FR-CRM projects focused on erosion control, often in seasonal, second and third order streams. Ephemeral streams were discharging disproportionate sediment loads into downstream perennial stream reaches.

It is important to note that all projects are voluntary, with full landowner cooperation, and designed to achieve maximum onsite and downstream benefits. Appendix D describes downstream effects for other water rights holders resulting from the projects, and also provides an example of the FR-CRM's experience in coordinating these types of projects with other affected parties.

Legend

Streams
Lakes and reservoirs
Rivers

Major River Drainages

Middle Fork Feather River
North Fork Feather River
South Fork Feather River
West Branch Feather River

FIGURE 4.9

UPPER FEATHER RIVER
MAJOR RIVER DRAINAGES

Watershed base map depicting the major river drainages of the North, Middle, South, and West Branch Feather River. The water from each major river drainage flows into Lake Oroville.

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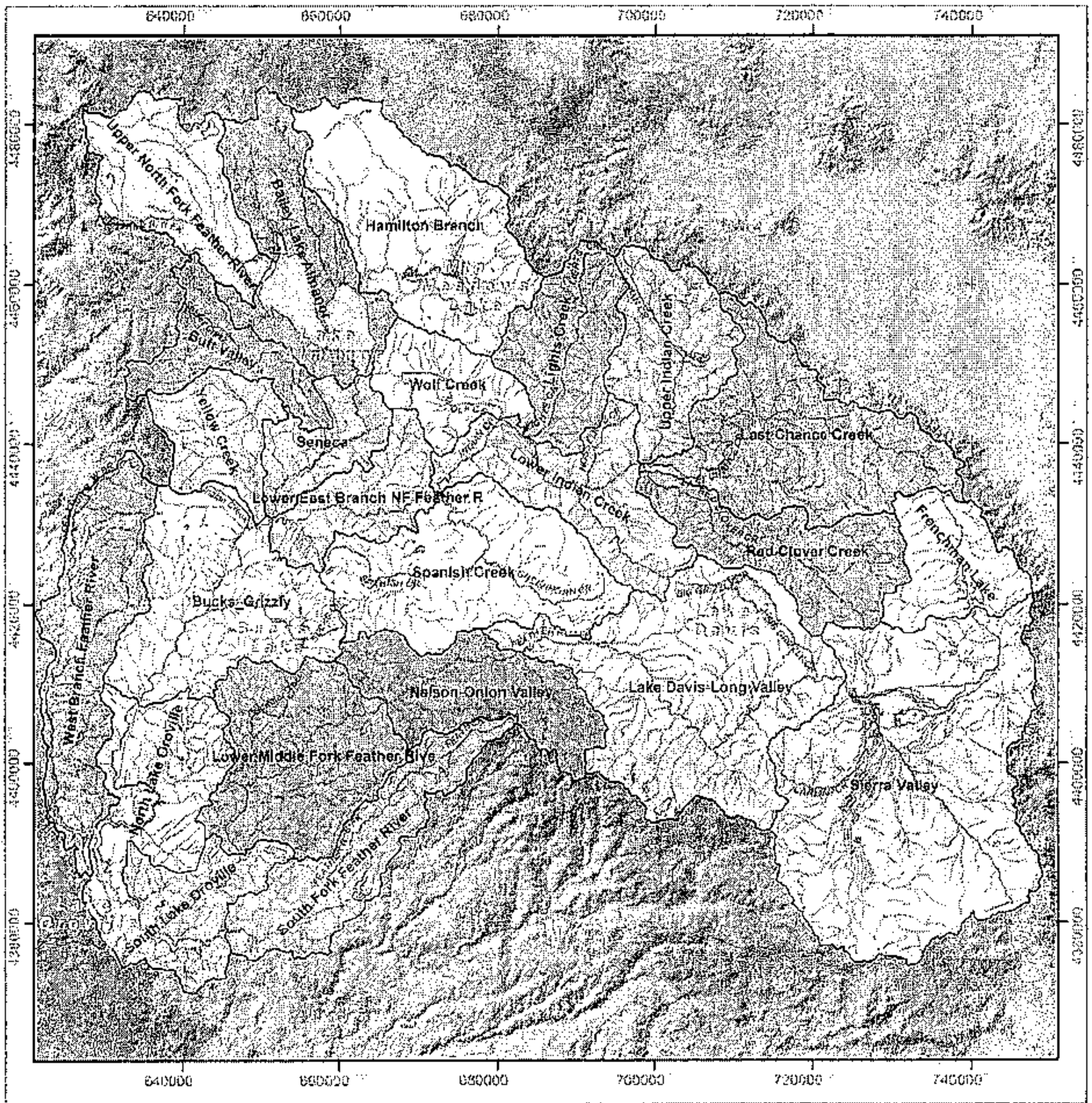

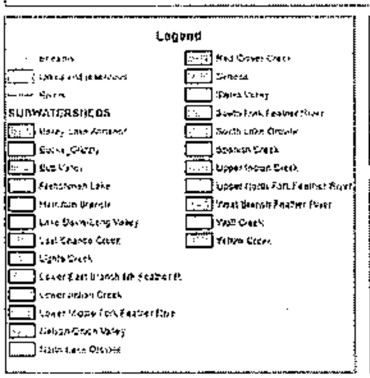

FIGURE 4.8

UPPER FEATHER RIVER SUBWATERSHEDS

Subwatershed base map depicting smaller hydrologic catchments within the greater watershed.

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GIS Metadata Information
Subwatershed delineation shapefile:
California Spatial Information Library CASIL

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All studies referenced and quoted in this report are available on the FR CRM website at www.Feather-River-CRM.org under "Publications."